NATURE

No. 4499 SATURDAY, JANUARY 21, 1956 Vol. 177

CONTENTS

	Page
Broadcasting, Television and Current Affairs	101
Genetic Problems of the Atomic Age	103
Challenge of Automation. By E. F. L. Brech	104
Human Factors in Undersea Warfare. By Sir Frederic Bartlett, C.B.E., F.R.S.	105
Automatic Feedback Control. By Prof. A. Tustin	106
New Underwater Hydrodynamic Research Laboratories. By F. S. Burt	108
Use of Solar Energy. By Dr. Harold Heywood	110
Large-scale Weather Processes	113
Population of British Universities in the 1960's: the Age-group Bulge. By Prof. R. G. D. Allen	115
News and Views	116
European Association of Exploration Geophysicists: Meeting in London. By L. H. Tarrant	120
Structure of Semi- and Non-Crystalline Materials. By Dr. U. W. Arndt	121
Density of the Lunar Atmosphere	123
Insecticides and the Balance of Animal Populations	123
The Second Entomological Expedition to the Himalayas. By Prof. M. S. Mani	124
A Modified Method of Two-Dimensional Zone Electrophoresis applied to Mucoproteins in Serum and Urine. By R. L. Markham	125
Cyclic Polyamides from Nylon 6 and 6.6 Polymers. By Dr. P. H. Hermans; C. J. Brown, A. Hill and P. V. Youle; M. A. Thorold Rogers	126
Letters to the Editors:	
Filamentous Forms of Influenza Virus.—Sir MacFarlane Burnet, F.R.S.	130
Reactivation of Partially Degraded Tobacco Mosaic Virus.—Roger G. Hart	130
Multiplicity Reactivation of Bacteriophage.—H. J. F. Cairns and G. S. Watson	131
Composition of a Hypertensin Peptide.—Dr. W. S. Peart	132
Effect of Antibody on the Respiratory Rate of *Trypanosoma vivax*.—Dr. R. S. Desowitz	132
Splitting of Aesculin by Yeasts.—J. A. Barnett and Dr. T. Swain	133
A Dielectric Study of the Low-Conductance Surface Membrane in *E. coli*.—Dr. Hugo Fricke, Herman P. Schwan, Kam Li and Vernon Bryson	134
Kinetics of Photosynthesis and Photo-inhibition.—Dr. B. Kok and J. A. Businger	135
Molecular Weight of Algal Chloroplastin.—J. J. Wolken and F. A. Schwertz	136
Influence of Thyro-parathyroidectomy on the Hæmatological Changes induced by Cortisone in the Rat.—M. P. Brogi and Q. Maggiore	138
Plasma Protein as a Precursor of Rat Liver and Hepatoma Protein.—Dr. P. N. Campbell, H. E. H. Jones and Nancy E. Stone	138
Electrical Responses of Certain Lepidopterous Tympanal Organs.—Dr. P. T. Haskell and P. Belton	139
Chromosomes of Five Rodent Species.—C. E. Ford and J. L. Hamerton	140
Cytoplasmic Inheritance in *Culex*.—Hannes Laven	141
Influence of Temperature on the Histological Evolution of the Ovotestis of *Cepea nemoralis* L.—J. Bouillon	142
Photostimulation of an Equatorial Bird (*Quelea quelea*, Linnæus).—Dr. A. J. Marshall and H. J. de S. Disney	143
Yield Stress of Clay-Water Systems.—Dr. A. Packter	144
Carioazulene, Natural and Synthetic, derived from Caryophillene.—Dr. N. Botafogo Gonsalves, M. A. Reis Cavalcanti and Djalma Paiva	145
Urea Adducts of Glyceryl Esters.—Dr. Francis Aylward and P. D. S. Wood	146

Editorial and Publishing Offices of Nature

MACMILLAN & CO., LTD., ST. MARTIN'S STREET, LONDON, W.C.2

Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual Subscription £6, payable in advance, postage paid to any part of the world

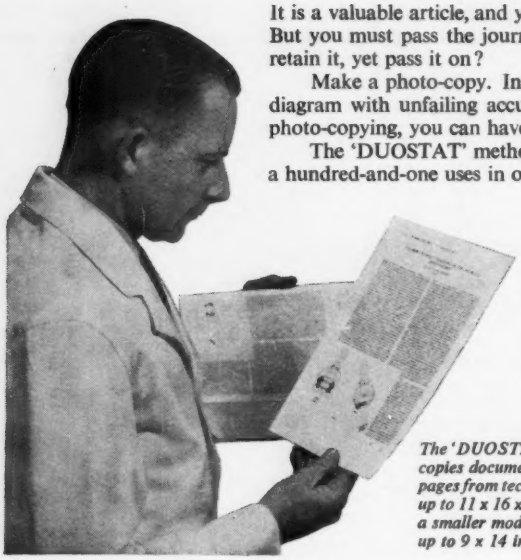
Advertisements only should be addressed to

T. G. Scott & Son, Ltd., Crown House, 143–147 Regent Street, London, W.1

Telephone Number: Regent 3891

All rights reserved. Registered as a newspaper at the General Post Office

An article from 'NATURE'



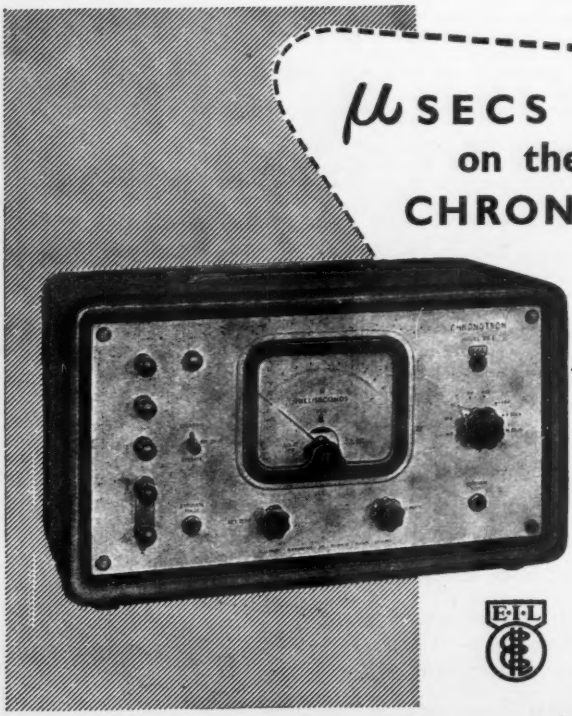
It is a valuable article, and you wish to retain it for personal study and reference. But you must pass the journal on to others in your organisation. How can you retain it, yet pass it on?

Make a photo-copy. In this way you can reproduce every word, symbol and diagram with unfailing accuracy. And, if you use the 'DUOSTAT' method of photo-copying, you can have your copy in less than three minutes.

The 'DUOSTAT' method is convenient, clean and inexpensive. And it has a hundred-and-one uses in offices and laboratories. Let us send you details.

Kodak
LIMITED
Industrial Sales Division
Kodak House, Kingsway
London, W.C.2

The 'DUOSTAT' Printer Model 14|18 copies documents up to 14 x 18 inches, pages from technical journals and books up to 11 x 16 x 1½ inches. There is also a smaller model for copying documents up to 9 x 14 inches.



μSECS TO SECS
on the new
CHRONOTRON

This new version of the well known Chronotron Millisecond Meter has eight ranges and measures time intervals from 100 microseconds up to 10 seconds with an accuracy generally better than 1% f.s.d. The Chronotron is an electronic stop-clock and over 1,000 instruments are in use all over the world, timing relays, switchgear, projectiles, camera shutters and physiological reactions.

E·I·L

ELECTRONIC INSTRUMENTS LTD
RICHMOND SURREY

E10

BROADCASTING, TELEVISION AND CURRENT AFFAIRS

THE directive issued by the Postmaster-General on July 27, 1955, to the British Broadcasting Corporation, and also to the Independent Television Authority, restraining either body from arranging to broadcast discussions or *ex parte* statements on issues within a fortnight of their debate in the Houses of Parliament, or while the issue is being debated, has been the subject of repeated questions in Parliament during the past few months. This directive, known as the fourteen-day rule, also vetoes broadcasts by any member of Parliament on any subject of legislation in the period between the introduction of the legislation and the time when it either receives the Royal Assent or is previously withdrawn or dropped. It has also been much discussed in the Press prior to the full debate on broadcasting anticipation of Parliamentary debates which, in deference to growing pressure, the Government arranged on November 30.

It was stated by the Prime Minister on October 25 that the directive imposes no new restrictions upon broadcast discussion, but requires conformity to a practice followed, in its present form, by agreement between the British Broadcasting Corporation and the major political parties since 1948. As explained, however, by the Postmaster-General in opening the debate, by 1953 the Corporation was dissatisfied with the situation and suggested that it alone should assume responsibility for deciding what subjects should be discussed. It did not, as the Corporation's annual report for 1954–55 shows, challenge the principle that broadcasting should not be allowed to encroach on the position of Parliament as the supreme forum for the discussion of public issues. It did, however, insist that if the rule was to be continued, it should be in the form of a directive on the Government's responsibility.

It was clear from the speech of the Postmaster-General that what most concerns the Government is the immense power of broadcasting, including television, over the minds of men. The fear that this power to influence public opinion may undermine or discount that of a political party inclines those in power to overlook the importance of examining the potentialities of such a new medium, of welcoming the opportunities of educating public opinion which it offers and determining the ways in which those opportunities can be most wisely and effectively used to widen the boundaries of public discussion, argument, knowledge and criticism. The Postmaster-General, it is true, admitted that broadcast discussion differs from discussion in Parliament or in public meetings generally. It differs also from discussion in the Press, and these differences in the technique required have more influence than most speakers in the debate were inclined to admit on the selection of broadcasters, whether or not they be members of Parliament. If the full advantages of broadcast discussion are to be realized, the choice of speakers must depend on their broadcasting ability and not primarily on their Parliamentary reputation or their standing with a party caucus.

The most disappointing feature of the debate was, however, the failure of any of the Government spokesmen to show any appreciation of those factors in the situation to which Sir William Haley, for example, directed attention in his Clayton Memorial Lecture in Manchester in March 1954. There was no evidence that broadcasting and television are regarded as in any sense instruments of education (at least by a majority of listeners), or of the urgent need for positive measures to counteract their erosion, for example, of standards of literacy. It is not the slender reporting of Parliamentary debates in the Press or the prior broadcasting discussion of the subjects of debate that undermines the prestige and authority of Parliament; there has always been such public discussion of live issues in the Press and in the streets and clubs and other places where people meet; rather the political party machine has reduced the significance of Parliamentary debate by making its issue a foregone conclusion.

One of the gravest blows struck at the dignity and prestige of Parliament is the disappearance of the independent member, and Sir Robert Boothby rightly reminded the House that it is its own actions rather than those of any other body that can detract from or uphold its dignity. So far from public discussion on parliamentary issues outside the House destroying the reality of Parliamentary debates, members down the centuries have relied on the cut and thrust of such debates to give vitality to their own arguments. It is true that there are occasions when restraint is called for and when broadcast discussion may be inexpedient, just as there are occasions when discussion in the Press is undesirable. If, however, sections of the Press fail to exercise the restraint which decency and the public interest dictate, the remedy lies rather with the public itself than in the imposition of a censorship.

Quoting Lord Beveridge's words, "No argument of merit can justify stifling the discussion of public issues at the moment when discussion is most opportune", Sir Robert Boothby said that Parliament should welcome free discussion as a guide to what people are thinking and how they feel. It is true that there is not quite the same alertness in broadcast debate as in a public meeting, but only the most superficial observer can fail to notice how quickly errors are noticed and how firmly opinions are challenged. There is little doubt that Sir Robert is right in suggesting that 'front bench' politicians over-estimate the power and influence of the medium.

Although the debate ended with the adoption of the Postmaster-General's motion, accepting the principle of some limitation to the anticipation of Parliamentary debates by broadcasting, and welcoming the appointment of a Select Committee to consider whether any changes are desirable in the ways in which effect is given to this principle, it became quite

clear that many members of all parties feel strongly that party leaders are attempting to keep far too tight a hand on public discussion out of Parliament. At least it was recognized that fourteen days is much too long a period for any such restraint to be maintained, and from all sides the absurdities into which the present rule might lead were freely emphasized. It was indeed contended by Mr. M. Edelman that the motion was in effect an admission that the rule is unworkable. It is to be hoped that the Select Committee will speedily arrive at some sensible proposals which, while indicating where restraint or reticence is appropriate, will safeguard the vital principle of free public discussion and the right of members of Parliament to speak their minds outside as well as within the House of Commons.

These matters concern all who are interested in seeing that the full potentialities for good of broadcasting and television are utilized, in education, in science, and elsewhere. The debate on November 30 should perhaps dispose of the idea that Parliament is, or ever was, the main forum of public discussion. It also indicated the danger of any attempt to curb controversy by some mathematical adjustment to the composition of the House of Commons, a danger which is brought out vividly in the lively attack on monopoly and the political party caucus which Mr. John Irwin has launched in his witty but provocative little book, "My Time is My Own"*. In an outspoken plea for free speech and for alternative broadcasting programmes, he shows clearly how fatal to entertainment and to public education alike subservience to the susceptibilities of the political party machines can be. If democracy means anything at all, he argues, it means trusting the people to think and decide for themselves; and if television and broadcasting are to be effective and present all major public issues competently, the deciding factor must be the appropriateness and efficiency of the programme and broadcaster for the task to be done.

Mr. Irwin's rather slight little book is worth reading for the evidence it supplies of the importance of securing vitality in broadcasting. It should be obvious that if the full opportunities which open discussion affords of enabling people to understand the real issues involved in matters of public policy are to be used, it can only be while the matter is of live interest and engaging the attention of Parliament. When it has been settled by Parliament, it may no longer hold the attention of the public, and the opportunity of explaining some of the factors that have determined government action may have been missed. This can be particularly important in respect of the technical and scientific factors involved in public policy. Even with the aid of the Parliamentary and Scientific Committee, we cannot assume that the exposition in Parliament is at present, or will be in future, such that members of Parliament fully appreciate the significance of such factors or are able to bring them out in debate.

Under the present fourteen-day rule, however, a valuable means of correcting this weakness and enlightening public opinion is lost. Atmospheric pollution, the development of nuclear energy, the hydrogen bomb and the hazards from test explosions, water supply, the preservation of the countryside, transport—on all these and many other topics expert opinion is more likely to be found outside Parliament than within, and it might be difficult for effective warning of the dangers of some proposed action to be given until too late, for we have to reckon with the possibility of the Press reaching a diminishing audience. Much more use in fact should be made of broadcasting and television as a means of raising the standard of public understanding of scientific and technical matters, and more thought and experiment are required as to the appropriate techniques to be used for this purpose. These will obviously differ according to the type of audience or viewer to be approached. The House of Commons debate showed, indeed, that several members appreciate how the fourteen-day rule could operate to discourage or prevent the education of the public in this way.

On the Government side at least, there was no attempt to distinguish between propaganda and educational broadcasting. Yet even in the political field, the distinction can be drawn; and in fact it must be made if broadcasting is to be used as an educational instrument. What must be recognized, however, is that the choice of broadcasters and the nature of the broadcast should be determined objectively solely in relation to the purpose to be served. Any attempt to subject the content of the broadcast or the choice of broadcaster to the predilection of a particular political party would be fatal.

In one respect the observations on the influence of broadcasting on the modern child, made in the study of the influences affecting the upbringing of young people recently conducted by the Council of King George's Jubilee Trust, are reassuring. Indeed, despite the growth of radio and television, the working party which inquired into the period of full-time attendance at school thought that the printed word remains the most widespread and influential medium affecting the child of school age and was more concerned with the raising of standards in the Press. In view of the inquiry into the influence of television on children and young people generally, now being conducted by the Nuffield Trust, the working party concerned with the influences of leisure time after leaving school did not consider television specifically; nevertheless, the report suggests that, hitherto, radio and television in Great Britain have maintained a good standard. While, however, the influence on juveniles of adult films, newspapers and radio programmes is often exaggerated, there is much evidence that their cumulative effect on standards of taste and values is considerable. It will be remembered that Sir William Haley stressed the dominant influence of British broadcasting on manners, but he was equally concerned as to the effect of television upon the very possibility of educational broadcasting.

The function of broadcasting as an incidental result of the maintenance of high standards, or pursued as a definite objective in the Third Pro-

* My Time is My Own: An Irishman at the B.B.C. By John Irwin. Pp. 111. (London: Max Parrish and Co., Ltd., 1955.) 8s. 6d. net.

gramme or in other ways, was strongly emphasized by the Beveridge Committee. It may be recalled that the majority itself was convinced that the group listening scheme had considerable educational potentialities, and that—through the Third Programme at least—a more determined effort should be made to encourage the participation of the audience and so increase the citizen's understanding of the world around; but a minority held that the B.B.C. had already put up powerful resistance to the attrition of standards in a democracy. In particular, it urged that the B.B.C. is to some extent supplying the unifying force required to make a democracy a real community, and that the pursuit and practice by the B.B.C. of the democratic values of truth and fairness, as well as of quality, are specially important in this respect.

This function is hindered, if not endangered, by the fourteen-day rule. If it is the function of radio and television in a democracy to ventilate views, the B.B.C. cannot continue to accept a restriction which any newspaper editor would reject forthwith. The Beveridge Committee, for example, observed that "if broadcasting can find a serious audience it is an unrivalled means of bringing vital issues to wider understanding". It can only do so if it is allowed to function freely while the issues are alive; but the attitude of the political party leaders hitherto almost suggests that they are not anxious for a wider and fuller understanding. None the less, the security and welfare of the nation depend increasingly on policy being based on the facts of the situation and not on particular political theories or prejudices. Equally they frequently demand action calling for public co-operation in ways that can only be assured if there is full understanding of what is involved. As Mr. M. L. Jacks wrote in his recent book, "Education of Good Men": "The man in the street needs to be set free from the forces which would mechanise his mind . . . and it is for education to set him free".

Broadcasting, as well as television, could and should be one of the forces which promote such education. The Beveridge Committee rejected the idea of an advisory council on adult education; but had such a council been in existence it would have been well placed to point out authoritatively the real dangers which attend the continuance of the fourteen-day rule, and how it can hinder the fostering of the awareness not only of society, but also still more of the relations which membership of a society involves, and in particular of its far-reaching duties and obligations—duties and obligations of which the rule itself is essentially the negation. Still more effective, however, might well be a determined attempt on the part of the Workers' Educational Association and professional bodies to use to the full the opportunities which broadcasting offers for bringing to the public understanding the essential factors in some problem of national importance whether or not it is currently engaging the attention of Parliament.

The limitations of broadcasting were emphasized by Sir William Haley in the Clayton Memorial Lecture already noted, and because of those inherent limitations, broadcasting needs supplementing if its educational possibilities are to be realized. It is to the development of the appropriate techniques, both in respect of adult education generally and in relation to those needs of a technological society to which Mr. M. L. Jacks and the King George's Jubilee Trust direct attention, that the Workers' Educational Association and professional institutions should be giving much thought and experiment. The techniques must be developed which will enable us to seize the opportunities which the unique power of broadcasting to stimulate public interest presents, provided it is allowed to choose its topics when they are alive and to entrust their handling to men and women chosen, not for their political party loyalties, but for their technical competence in broadcasting, their personal integrity and their vision and sense of public responsibility.

GENETIC PROBLEMS OF THE ATOMIC AGE

WITH an editorial and three articles, by M. Westergaard, H. J. Muller and R. E. Lapp, respectively, the *Bulletin of the Atomic Scientists* (11, No. 9; November 1955) begins a systematic discussion of the genetic aspects of the atomic age. M. Westergaard, professor of genetics in the University of Copenhagen, writes on "Man's Responsibility to his Genetic Heritage"; this article had already appeared in Unesco's review, *Impact* (6, No. 2; June 1955). It is an exceedingly clear exposition of the principles of genetics, of the effects that changes in environment, on one hand, and in mutation-rates, on the other, may have on the genetic constitution of future generations and of the responsibility that we have towards them from these two aspects. It is probably the best general account for the public of what the genetic problems of the atomic age are, and what kinds of ethical and practical issues they raise.

H. J. Muller writes on "How Radiation Changes the Genetic Constitution". This is the paper which Prof. Muller would have delivered at the Geneva Conference on the Peaceful Uses of Atomic Energy had he not been prevented at the last moment by decision of some cautious administrator. The editorial, "Genetics in Geneva", deals extensively with this remarkable episode and its implications.

If it had been read, Muller's article would certainly not have made headlines as some of the less competent pronouncements at that Conference did. It is a profound appraisal of the present knowledge of the genetic effects of ionizing radiations. Its interest is in two directions. First, it gives new estimates for human populations: (*a*) of the increase in the

rate of deleterious mutations expected from increased radioactivity; (*b*) of the present 'load', that is, the level of deleterious mutant alleles already present; and (*c*) of the natural mutation-rates. All three estimates are, of course, in part conjectural, and Muller stresses the urgent need for far more research. But they are the best that can be done with what is available.

Secondly, at each step in these calculations Muller expounds very fully every aspect of the argument. The estimates may not go on being acceptable for long, as more reliable data come in; but Muller's arguments and treatment will remain very useful for a long time. Here probably lies the outstanding value of this article.

The three estimates are: (*a*) for the increase in the mutation-rate following irradiation: at least one mutation per germ cell per about 450 r., considering only lethal mutations and those reducing the fitness of the homozygote by not less than 10 per cent; (*b*) for the present 'load' of such mutations: 6·5–8 per individual; and (*c*) for the rate at which such mutations arise 'spontaneously' in man: about 8 per hundred germ cells.

There are a number of interesting consequences which Muller deduces from these estimates. One is that only about 40 r. applied to a population would be sufficient to double its natural mutation-rate: this is a dose which, spread over some fifteen years, some radiologists may already be receiving. Another deduction is that natural radioactivity may account for about one-sixth of the spontaneous mutation-rate in man. A third deduction is that the loss of fitness in the first generation after Hiroshima cannot be perceptible. Over an existing load of 6·5–8 mutations per individual, an extra one due to parents *both* irradiated with as much as 225 r. would not be detectable under the crude conditions of collection of data. Yet the serious genetic damage is there: some of it is being paid for by the first generation, and the bulk will be spread thinly over innumerable future ones. Muller's article sets out very clearly the apparent contradiction between the amounts of serious genetic damage done and the fact that its consequences are not evident: "even though the induced mutations may be many times the number that would arise naturally in only one generation, they are nevertheless few in relation to the accumulated natural 'load'. Hence they can raise by only a rather small percentage the number of genetic shortcomings already present in the population". It would, of course, be impossible for a population to "tolerate generation after generation an exposure which, given to only one generation, would cause no perceptible deterioration". It is precisely this condition that we have to appraise when considering the genetic consequences of the industrial use of atomic energy, as distinct from those of the military use.

The article by Lapp—"Global Fall-out"—makes very interesting reading for the non-physicist. It deals, however, with fall-out after super-bomb tests, and international agreements to stop these tests should not be far away. As to fall-out in war, the immediate consequences would be final enough for the whole of mankind: it does not seem to be worth while thinking about the genetic consequences.

The editorial, "Genetics at Geneva", deals with the facts and the implications of the 'muzzling' of Prof. H. J. Muller at the Geneva Conference. Prof. Muller is unquestionably the foremost authority in the world on radiation genetics. The rather pitiful series of episodes—already reported in the daily Press, and given again in detail in this editorial—has had, of course, a very beneficial effect: many more will carefully read Muller's paper. It is, however, another example of the threat to the integrity of science recently analysed by Piel (see *Nature*, 176, 1134; 1955). It also shows how dangerous it is to have research on the long-term effects of radiations—a matter of supreme concern for the industrial uses of atomic energy—carried out in the same laboratories and under the same administration as research with an essentially military outlook.

CHALLENGE OF AUTOMATION

The Practice of Management

By Peter F. Drucker. Pp. viii+355. (London: William Heinemann, Ltd., 1955.) 25*s*. net.

ANY review of the British edition of this book must begin by echoing many of the praises that have been sung in the intervening few months since the American original first appeared. The praises are deserved—in the sense that the book is dynamic, stimulating and challenging. The echo is right, too, in the invitation to every manager and official in British industry to read the book. But, at least in the mind of the present reviewer, there is a limit to which the fervent adulation should go.

To appreciate the tone and tenor of these tumultuous three hundred and fifty pages, it needs to be recalled that the author, Mr. Peter F. Drucker, is a sociologist by interest, and an industrial investigator by adoption. He has looked at American industry from the top down and has had the fortune—good or bad, according to one's point of view—to look from the top of very big heights. One of his best-sellers was called "Big Business", and the aura of bigness rather than greatness surrounds his latest accomplishment.

Lest this cool comment be taken unfairly as criticism, let it be said that Drucker starts off his volume by disclaiming any intention of writing on the techniques of management; but he did set out to produce a practical book. The reader, as the product turns out, gets a great deal of guidance and help on how not to do things in management, but it is by implication that he is expected to learn what to do and how. The informed reader will come away with a vivid impression of having seen all this before, perhaps not with so invigorating a degree of excitement and incitement. The newcomer to the subject will hug the book to his breast as an indispensable vade-mecum in the toilsome journey through the tasks of executive management.

"The obstacles to the 'automation revolution' are great—above all, the lack of men properly trained in the new concepts and skills." This sentence is perhaps the bedrock of the study: but the skills concerned are not thoroughly technical and intricate, in the vein of electronic brains, elaborate computa-

tions and complex mechanisms. They are, instead, the age-old simple skills of motivation and the promotion of morale—not just a re-hash of old personnel management and human relations but the deeper and more vital process of making management a leading force of all efficient operating. "Managing managers is the central concern of every manager" is a recurrent theme throughout Drucker's thought, and it is in this regard that the responsible reader feels most keenly the lack of practical approach: a whole Part of the book is devoted to the theme, but one comes away from it with little more than the inspiration contained in the theme itself.

The fifty pages devoted in Part 3 to "The Structure of Management" are among the most valuable of all. Again, the knowledge is nowhere new; but sound teaching is realistically conveyed, and the notion of 'federal decentralization' is a helpful concept in these days of large and complex organizations. Clearer understanding of Drucker's thesis in this direction would be of immense practical value to the managers and officers of many a British undertaking, including those in the nationalized industries.

Here and there occur items which leave the serious reader much puzzled as to why they are given the degree of emphasis in treatment—unless these are the instances where the author's own lack of practical insight have led him astray. For example, a whole chapter in Part 1 is devoted to considering the objectives of the business, and in the event it says little more than the paragraph of half a century ago wherein F. W. Taylor pleaded that all management decisions should be based on facts and the due analysis of what such facts reveal. Or again, much later in the book the position of the supervisor is surveyed, and recommendations are made about enlarging his responsibilities and the scope of tasks entrusted to him. One is left wondering what sort of a role the representative supervisor has in American industry if the enlargement here called for is so revolutionary: "If the supervisor has a genuine manager's job, if he is adequately supported by his own staff, if he has real authority, and if his unit is big enough—then his job will have become manageable again".

The chapters inquiring "Is Personnel Management Bankrupt?" will also excite considerable interest among British readers, especially those whose own recognition of the need for specialist personnel assistance has been grudging, if existent at all. But they will be disappointed, for Drucker's answer is in the negative, and his two chapters (22 and 23) on how it can best make its mark are indeed valuable.

It would be a pity to let criticisms of detail hinder the widespread acceptance of an important work, and the foregoing comments have been made in the interests of maintaining a correct perspective. The book is long—in fact, too long for the type of contents that it offers. Yet it is easily readable and has a facile style that makes for ready absorption. Its title, however, can be misleading, and, at a time when reliable information about management action is being avidly sought in Britain, it seems dangerous to let a possibly disappointing source pass by unmarked—disappointing, of course, only in the sense in which the author himself avers that his book does not intend to teach the techniques. To some readers it may, perchance, be disappointing in other directions: for example, the emphatic restriction of 'management' to the business world (that is, the making and marketing of products), whereas in Britain we accept management as equally pertinent in service spheres, in government and in a multitude of non-commercial activities; and did not Mooney and Reiley a quarter of a century ago in the United States claim that the major factor about management was its universality?

To me the main disappointment lies in the basic acceptance of the superficially popular cliché that "managers are born, not made". Leadership is, indeed, as Drucker says, "important and has no substitute". But to go further, as he does (". . . cannot be created or promoted . . . taught or learned . . ."), is to fly in the face of experience and to run counter to the mature thought of several highly respected thinkers going as far back as Mary Follett in the early 1920's, or Henri Fayol at the turn of the century.

E. F. L. Brech

HUMAN FACTORS IN UNDERSEA WARFARE

A Survey Report on Human Factors in Undersea Warfare

Prepared by the Panel on Psychology and Physiology. Pp. x+541. Supplement. Pp. ii+92. (Washington, D.C.: National Academy of Sciences—National Research Council, 1949 and 1954.) n.p.

IN 1946 the United States National Research Council appointed a Committee on Undersea Warfare at the request of the Office of Naval Research. This Committee set up a Panel on Psychology and Physiology, and asked the Panel to "draw up an outline for a survey of basic and applied research on problems related to the human factor in undersea warfare". This the Panel did, and then selected a number of authors who were known for their scientific work in the various fields to be covered, and asked them to produce written reports on topics indicated. Few, if any, of these experts had had direct experience of submarine problems, but it was thought that this would be an advantage rather than a handicap, since "a fresh and somewhat detached point of view might prove valuable in pointing up new problems".

Most of the reports were prepared during 1947–48, and the volume now under review was first published in 1949. At that time four of the papers—the night lookout; the design and use of optical instruments; visual display of complex information; and arrangement of equipment—were considered to contain material which should be treated as secret. These studies have now been declassified and are issued for public circulation as a supplement to the main volume.

The topics dealt with are: general visual problems; design and arrangement of operating equipment; auditory problems; communication; habitability, physiological and psychological; emotional stability and adjustment; selection and training; and personnel resources. Practically everybody who is actively concerned with human aspects of submarine and related operations should already be familiar with nearly everything that is reported and discussed in this book. Moreover, an immense amount more of experimental work has been carried out during the past six or seven years on all the matters raised and on many others. In numerous ways also, the nature and probable tactics of undersea warfare have changed somewhat radically, with the result that

new problems have developed and some of the old ones have changed direction and practical importance.

Nevertheless, this remains an outstandingly valuable source and reference book for the submarine expert, and for many other types of reader it may well come as a revelation of what well-planned physiological and psychological research can accomplish. A great many of the problems considered are of enormous importance in current industrial organization: for example, how to arrange maps and charts and measuring devices on all kinds of optical and other instruments; how to design machine controls and to arrange instrument panels and equipment generally; how to study intelligibility and range of communication, visual and auditory; and how to find out the effects of extremes of temperature, humidity, noise and other forms of stress.

The fact that the whole book has been seriously written by scientists whose principal interests are in fundamental research means that, although the reports now need much supplementing in detail, the data that are reported are almost all thoroughly well accredited, and the methods and procedures described are of wide and permanent interest.

Considering the range of topics covered, and that thirty-four authors have contributed papers, the consistently high level maintained is remarkable. If, however, I had—rather unfairly—to choose one discussion as being of outstanding interest at the present time, I think I should select Dr. J. W. Gebhard's article on visual display of complex information (Supplement, pp. 39–66). His particular concern is with "the problems of an information centre which must handle and interpret diverse ever-changing data collected from many sources". There is no better brief account anywhere of what was known about such problems up to the beginning of 1949, and many of the critical problems which were then pressing have become still more urgent since. All the displays dealt with necessarily present the information to be communicated in coded form. Obviously the human sense organs and brain must also, in their own ways, code observed information for storage and recall. It is of great general interest, therefore, that some of the codings used in radar, sonar and other systems of display should be more fully and immediately accessible to the normal operator than others. Further, the question, which in this article is critically considered and very clearly illustrated, of how many dimensions of change can be simultaneously dealt with in the coded visual display remains still one of great practical importance and fundamental significance.

F. C. Bartlett

AUTOMATIC FEEDBACK CONTROL

Automatic Feedback Control System Synthesis

By Prof. John G. Truxal. (McGraw-Hill Electrical and Electronic Series.) Pp. xiii+675. (London: McGraw-Hill Publishing Co., Ltd., 1955.) 89*s*. 6*d*.

YOUNG American professors of electrical engineering, especially those who have studied at the Massachusetts Institute of Technology, often write books about automatic control, and the number of re-hashes of 'Brown and Campbell' is now considerable. It is a pleasure to find that Prof. J. G. Truxal's book, although it does not stray far beyond what is recognizable as 'M.I.T. thinking', is an advance on existing books. It presumes acquaintance with one or other of the introductory text-books, and gives an account of the many developments of the theory of feedback systems that have been made in recent years. Accounts are given, for example, of the 'root locus' method of Evans, of the 'pole-zero configuration' approach, associated with Guillemin, the statistical approach that was initiated by N. Weiner, and the 'describing function' and 'phase-plane' techniques for dealing with non-linear systems. There is also a chapter on sampled-data systems.

These and other facets of the subject are clearly presented and intelligently discussed, and although the book is largely a presentation of mathematical procedures that have been described elsewhere, there are many sections in which significant new contributions can be found. A book that brings the knowledge of its readers up to date in this way will be of great value.

The approach is mathematical and based throughout on the use of the Laplace transformation. The book is not intended for beginners, but as a supplement to introductory text-books on feedback systems and on the functions of a complex variable. Regarded as a presentation of the mathematical procedures now available, it is excellent, and will be valuable to advanced students and to designers. References to the literature could with advantage have been more complete. They are given, rather thinly, as footnotes, and confined mainly to American sources.

The value and high quality of this book being granted, it may nevertheless be questioned whether Prof. Truxal has quite justified the use in his title of the word 'synthesis'. It is true that analysis and synthesis are not separable, and that in contriving a control system to meet a specification it may be useful to consider such things as the patterns of poles and zeros of a linear transfer function. But true synthesis would imply a definite numerical procedure, without trial and error, starting from quantities given in the specification and ending with quantities defining the physical construction. It is probably impossible for progress in methods of synthesis to be made, as long as the discussion insists on the excessive generality of being applicable to feedback systems in general. It is possible to go much further if such systems are first classified. For well-defined classes of feedback system—say, for example, large positioning servo systems or automatically controlled distillation columns—one may make progress with the problem of synthesis or 'design for controllability', the parameters of the apparatus controlled being regarded as variables, as well as those of the controller.

The tacit assumption that some 'system to be controlled' is given, and that the only problem is the synthesis of separate control elements to be added thereto, has always been a shortcoming of the Massachusetts contribution in this field, and Prof. Truxal, in so admirably consolidating and even advancing this contribution, has tended to retain the restriction. Perhaps he would consider what the implications would have been if his title had been "The Synthesis of Controlled Systems" instead of "Control System Synthesis". But to suggest that an author might have written a different book is one of the vices of reviewers, and we may be grateful for this comprehensive, clear and well-produced book that will contribute to the further advancement of the development of automatic controls.

A. Tustin

Rapport Européees Congrès Toegepaste Electronenmicroscopie, Gent, 7–10 April, 1954

Edited by G. Vandermeerssche. Pp. 359. (Gent: Rijksuniversiteit, 1954.) 500 Belg. francs.

THE Centre for Electron Microscopy of the University of Ghent organized in April 1954 the first congress devoted solely to the applications, as opposed to the fundamentals, of the subject. Previous meetings of an international nature had covered all aspects, but the rapid advance in the uses of the electron microscope justified a conference with a somewhat narrower scope. The proceedings of the congress, published with commendable speed within six months of its termination, shows that the range of topic was still very wide, while the list of authors substantiates the title "European".

Eleven papers are concerned with the electron microscope itself and special methods of operation, such as the reflexion and emission techniques and electron diffraction. Another eleven papers cover medical and biological applications: ultra-microtomy, bacteria, viruses and fibrillar structures. Only five contributions deal with metallurgical problems, confirming the general observation that this field has been the slowest to find uses for a higher resolution than the optical microscope provides. On the other hand, a new trend of the past few years is strengthened by the amount of attention paid to chemical and industrial applications. Ten papers in this group cover a wide range of materials: ceramics, greases, textile fibres, metal oxides, clays and fluorescent powders.

The volume thus presents a useful picture of the present state of applied electron microscopy. It remains only to say that speed of publication has not led to any sacrifice in quality of production; the printing, binding, and reproduction of micrographs are alike excellent. The editor, who was also in charge of the organization of the congress, must be congratulated on the fruits of his efforts.

V. E. COSSLETT

An Illustrated History of Science

By Dr. F. Sherwood Taylor. Pp. xii+178. (London: William Heinemann, Ltd., 1955.) 25*s*. net.

AS a history of science this book increases our indebtedness to the late Dr. F. Sherwood Taylor, who did so much to present the results of intensive research in language that the ordinary reader can appreciate.

As an illustrated history of science it is unique. Based upon the 1953 Christmas Lectures at the Royal Institution, London, in which the author dealt with some of the historic experiments in natural science, it has, among others, illustrations relating to the apparatus and conduct of the experiments. These, from sketches drawn by A. R. Thompson, are built up around what could be discovered about the way of life in the times when the experiments were first made, and are not merely substitutes for photographs which might have been taken had photography been possible. They have a liveliness that makes the reader feel that he is an eye-witness of what was going on, when, for example, the Abbé Nollet felt the shock from a Leyden jar, or Sir Humphry Davy demonstrated the electric arc in 1808.

Beginning with the observations of the Egyptian priest-astronomers and the Greeks who studied science for its interest rather than its use, the author surveys the early days of experimental science and its remarkable progress during the eighteenth century, the work of men like Faraday, Kelvin, Edison and Crookes in the nineteenth, and the past fifty years during which "so much knowledge and power have come into men's heads and hands that they cease to think of science as some specialised occupation, but are coming to regard it as a way of understanding and organising any job of work". F. J. NORTH

General Microbiology

By Prof. William G. Walter and Prof. Richard H. McBee. (Based on the original text by Prof. D. B. Swingle.) Pp. ix+345. (New York: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1955.) 35*s*. net.

IN 1940 a book was published by the late Prof. D. B. Swingle, of Montana State College. It was entitled "General Bacteriology" and, as an introduction to the lower forms of life, was so well received that it was revised and issued in a second edition in 1947. Two of Swingle's successors at Montana, Profs. W. G. Walter and Prof. H. McBee, have now made a thorough revision of the earlier work and, as the title implies, have adopted a broader approach.

Some of the more recent aspects of bacterial cytology, genetics and nutrition are described to illustrate the growing importance of the study of bacteria as a means of illuminating some of the newer disciplines. A new section describes the mutual relations of micro-organisms, while chapters on pathogenic bacteria and viruses have been expanded. The book is extremely well illustrated and would form an admirable introduction to the study of microbiology for professional and lay readers. Its weakness is in the chapters dealing with applied bacteriology. The few pages on industrial microbiology, for example, are so scanty that they could profitably have been omitted to allow a wider treatment of a topic like the microbiology of milk products.

T. H. HAWKINS

Hydro-Electricity and Nature Protection

Stating the Case. Prepared by the Rt. Hon. Lord Hurcomb. (Pro Natura, Vol. 2.) Pp. 224. (Bruxelles: Union Internationale pour la Protection de la Nature, 1955.) n.p.

IN the summer of 1952 the International Union for the Protection of Nature held its third General Statutory Assembly at Caracas. A technical meeting was held at the same time which brought together two hundred experts representing thirty-two countries and five continents. One of the items discussed was "Hydro-electricity and the Protection of Nature". A volume of 550 pages containing the proceedings and the papers of the Caracas meeting appeared in 1954; but it comprised several subjects and it had also to be reproduced in three languages and principally in Spanish. As a result, the remarkable documentation on hydro-electricity that had been gathered from sixty preliminary reports, submitted to the Caracas Conference by specialists from all over the world, could not be used to the full extent of its worth.

A volume has now been prepared by the Right Hon. Lord Hurcomb, vice-president of the Union, with the aim of placing within the reach of the public as much as possible of the more important points of this documentation in an abbreviated form. Some of the papers are in French and some in English; a French summary is given of the papers published in English, and vice versa.

NEW UNDERWATER HYDRODYNAMIC RESEARCH LABORATORIES

By F. S. BURT
Admiralty Research Laboratory

THE Admiralty recently released information on the new Underwater Hydrodynamic Research Laboratories completed just over a year ago. These new facilities, which form part of the Admiralty Research Laboratory, Teddington, are to carry out fundamental research into the behaviour and characteristics of underwater bodies with the view of investigating the possibilities of making major advances in this comparatively unexplored field of hydrodynamics. The total cost of these facilities was just over one million pounds. The present article is published by permission of the Admiralty.

The most spectacular item of the equipment is the 60-ton rotating beam and annular channel which have been designed to investigate the behaviour of bodies moving at high speed under water. In addition, there are two water tunnels which are analogous to the wind tunnels used in aeronautical research. There is also a glass-sided water entry tank for investigating, on a model scale, the problem of the entry of missiles from the air into the water.

Rotating Beam Channel

The rotating beam channel, which is housed under a 160-ft. diameter dome, is used for the measurement of stability and control characteristics and also for the investigation of bodies of various forms moving at high speeds under water. The 122-ft. span rotating beam spins over the annular channel of rectangular section, 34 ft. wide and 15 ft. deep. The radius of the inner wall of the channel is 34 ft. and that of the outer wall 68 ft. The models, which may be up to 20 ft. in length, are normally run at a depth of 5 ft. and may be attached to the beam at alternative radii. The maximum speed of the beam is approximately 30 revolutions per minute, giving a speed of 150 ft./sec. at the 50-ft. radius or nearly 100 knots at the 55-ft. radius. The beam is driven by a 1,510-h.p. 600-V. D.C. motor controlled by a Ward Leonard set, and its speed can be controlled either manually or automatically to any speed to within 0·1 per cent of the top speed. For some of the tests it is necessary to obtain speed very rapidly and this is achieved by

Fig. 1. The annular channel and rotating beam. The windows of the inner observation chamber can be seen. The water is so clear that it is difficult to see it even in the original photograph

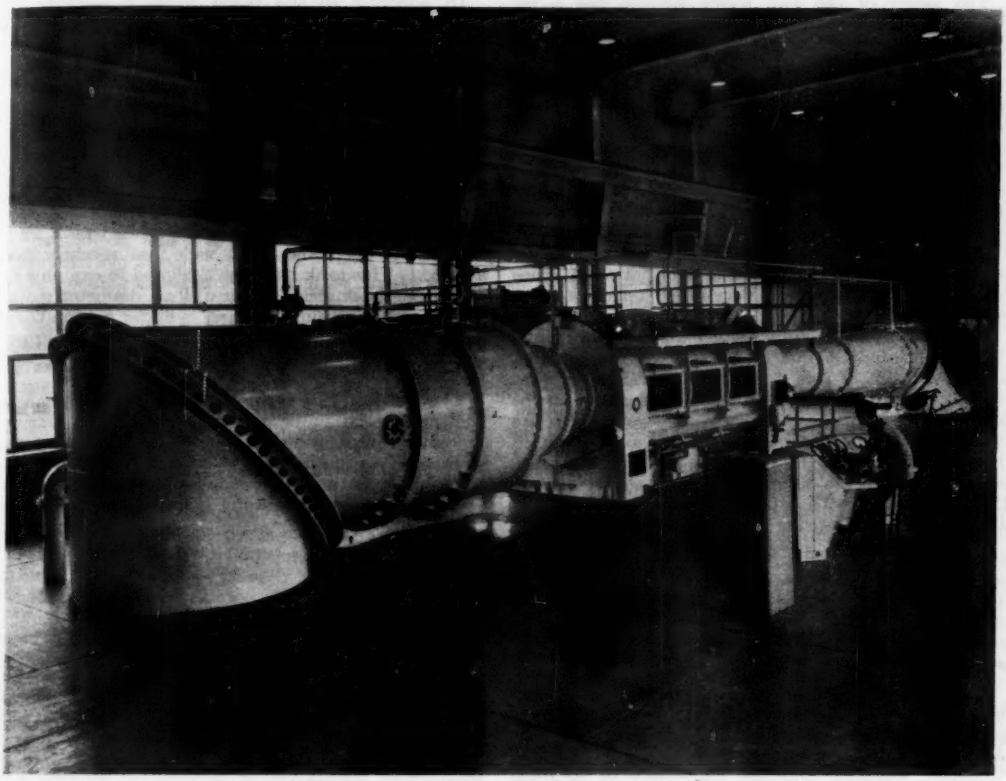


Fig. 2. The 30-in. water tunnel, showing the working section and the control console

over-running the electrical plant for short periods, enabling the beam to be got up to maximum speed in only fifteen revolutions.

At one section of the channel large windows are provided in both the inner and outer walls. The windows are made up of large 1¼-in. thick 'Triplex' panels through which the models can be observed. To enable high-speed photographs of the experiments to be taken, the million gallons of water in the channel is specially treated and filtered. By careful control the optical transmission of light in the channel is as high as 90 per cent per metre compared with air.

The models which are run in the channel and also those used in the larger water tunnel may be powered, and always contain within themselves the necessary instrumentation to measure any forces, moments or pressures that may be required. The resistance strain gauge, used in an A.C. bridge, is the standard transducer for all measurements.

The Water Tunnels

The first of the new major pieces of hydrodynamic equipment to be built was the water tunnel having a working section diameter of 12 in. This tunnel was designed to be as versatile as possible and has a variety of alternative working sections. The water speed can be continuously varied up to some 82 ft./sec. in the closed jet and up to about 62 ft./sec. in the slotted-wall working section.

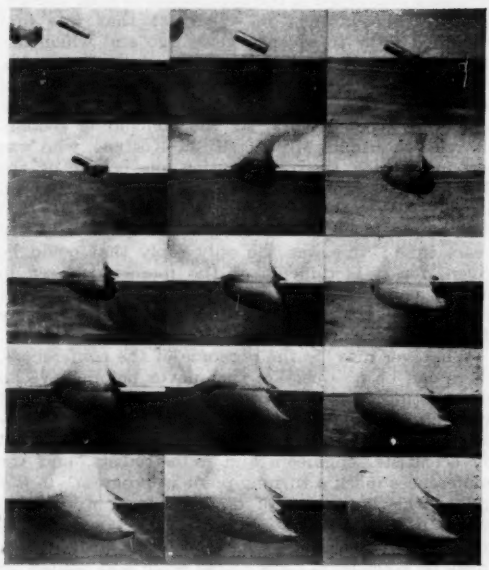


Fig. 3. Multiflash photographs (2 μsec., 110 joules) of a typical water-entry trajectory

The larger of the two water tunnels has a jet diameter of 30 in. and the speed is continuously variable up to 60 ft./sec. (35 knots). In both tunnels the pressure at the model can be varied between 2 lb. per sq. in. and 45 lb. per sq. in. absolute. Powered models cannot be made much less than about 8 in. in diameter, and much thought was therefore given to the design of a suitable working section. This resulted in the concept of a slotted-wall working section partially open and partially closed. The philosophy behind this idea is that the wall corrections of an open jet are very much less and of opposite sign to those of a closed jet, and by enclosing the open jet by a cage of bars one can in fact get the virtues of an open jet tunnel and a very much longer working section.

A considerable amount of development was done on the optimum layout of such a working section, and as a result of this it has been found possible to double the effective size of the working section, at any rate so far as tests on bodies of revolution are concerned. Hence powered models some 10 in. in diameter and up to 12 ft. long containing 100 h.p. can be tested in the 30-in. tunnel. These models are fitted internally with a five-component balance and also means of measuring the torque and thrust.

In addition to the novel working section, this tunnel is also fitted with a 'resorber'. This takes the form of four 11-ft. diameter passes up and down a 60-ft. deep pit, and by the combination of pressure and time re-absorbs any cavitation or gas bubbles that may have been formed in the working section during the course of the experiments.

Model Water Entry Tank

To assist in the study of the air-to-water entry behaviour of weapons, a new glass-sided tank 29 ft. long, 9 ft. deep and 5 ft. wide has recently been erected. This tank has been designed to examine the behaviour on entering water of 2-in. diameter models which are fired from a slotted cylinder catapult with entry speeds of up to 300 ft./sec., which on Froude scaling corresponds to about 1,000 ft./sec. full scale.

The virtue of this type of catapult is that it enables the models to enter into the tank with varying amount of pitch and yaw, which are vital parameters in these investigations. The models can be fired into the tank at any angle between horizontal and vertical, and high-speed photography is used to examine their behaviour.

USE OF SOLAR ENERGY

THE World Symposium on Applied Solar Energy and the Conference on Solar Energy, which were held recently in Arizona, have received considerable publicity. These conferences were sponsored by the Association for Applied Solar Energy, the Stanford Research Institute and the University of Arizona, with Mr. Lewis W. Douglas as the general chairman. That more than a thousand scientific workers, representing many nations, travelled to Arizona to discuss problems concerned in the application of solar energy, indicates the interest in a subject that was first exploited forty to seventy years ago and which has been intensively studied during the past ten years. Press reports from the conferences on the future of solar energy have varied from unqualified optimism to salutary pessimism. At the concluding session, the vice-chairman, Mr. Merritt L. Kastens, who was responsible for the organization on behalf of the Stanford Research Institute, said that he had been asked: "Were the conferences successful?" He said that he would be able to answer this question in ten years time; this was the only reply that could be given, for it is difficult at the moment to see in correct perspective the precise applications of solar energy that are economic, and the path of future developments.

Whatever may be the outcome of the conferences, there can be no question that never before have all the existing facts concerning the present position of research in the various applications of solar energy been presented simultaneously and freely discussed by scientists, engineers and industrialists, and the conferences mark a turning-point in progress. It was indeed this consensus of opinions from workers in many fields that gave unique importance to the meetings, for the problem of utilizing solar energy must be considered on a global scale and cannot be limited to the specific requirements of any one country.

The two meetings, held consecutively, were independent but complementary. The conference, which was held first in the University of Arizona, was for the purpose of discussing among scientific workers the basic problems that must be solved before solar energy can be successfully applied, with a detailed description of researches at present in progress for this purpose. The symposium, held in Phoenix, was intended to summarize the general position of solar-energy utilization and especially to acquaint industrialists with the problems involved, since successful development depends ultimately upon co-operation between science and industry.

Conference on Solar Energy

A total of nearly a hundred papers was presented at the Conference on Solar Energy, and this necessarily involved sub-division into a number of separate sessions. The opening session, of a general nature, dealt with the characteristics of solar radiation as emitted from the surface of the Sun and as received at the surface of the Earth, these studies being an essential preliminary to the study of utilization. Prof. Farrington Daniels also gave a general paper outlining the methods of utilization.

The remaining sessions, held concurrently, were as follows. Section *A*: Thermal processes comprising flat-plate collector design and the principles of selective radiation; solar furnaces for the production of high temperatures; solar energy for house and water heating, for cooking and water distillation; solar power machines. Section *B*: Photochemical processes comprising large-scale algal culture; algal physiology; photochemistry in higher plants and in non-biological systems. Section *C*: Electrical processes for the direct conversion of radiation to electricity, including thermoelectric generators, photovoltaic cells and $p-n$ junctions and photo-

galvanic cells. There was also a session devoted to a discussion of the measurement of solar radiation. The technical implications of these papers are discussed later.

World Symposium on Applied Solar Energy

The general scope of the technical papers at the World Symposium was similar to that of the papers presented at the preceding conference, but they were intended for an audience possessing a wider range of interests. Each author was a recognized authority on his subject, and presented this in the form of a comprehensive survey.

The opening remarks were given by Mr. Lewis W. Douglas, and were followed by an invocation delivered by the Right Rev. Arthur B. Kinsolving, Bishop of Arizona. Prof. Farrington Daniels, of the University of Wisconsin, who is doing so much to promote research on solar energy, and Dr. J. E. Hobson, director of the Stanford Research Institute, presented papers covering in a comprehensive manner the utilization and economics of the applications of solar energy. The principal speaker at the welcoming luncheon was Sir Edward Bullard, director of the National Physical Laboratory, who outlined the benefits that could accrue from solar energy, but also emphasized the difficulties involved in such developments. It was generally considered that his realistic speech counteracted the excessive optimism of those who were unaware of the true magnitude of the problem. At the banquet, Mr. John Jay Hopkins, chairman and president of General Dynamics Corporation, gave an inspiring address on the possibility of creating a World Energy Community by united governments to organize correlation of all energy resources. He emphasized the need to adapt our thinking to changing times and conditions in considering the relationship between the forces of atomic fission, fusion and applied solar energy.

An exhibition of solar appliances was arranged at Phoenix in conjunction with the symposium. Comparison was facilitated of the various schemes for house and water heating, for water distillation and for solar cookers. In this latter connexion efforts are being made by the research group at the University of Wisconsin to reduce costs by constructing the reflectors from aluminium-coated plastic instead of sheet aluminium. The largest single exhibit was an engine of Italian design, operated by sulphur dioxide vapour and used to drive a water pump. The National Physical Laboratory of India showed a small-scale model to illustrate its system of movable panels of mirrors which can be used to provide concentrated radiation for steam generation or other heating processes. Examples of solar furnaces were demonstrated and also some ingenious pumping devices operated directly by the action of vapour and liquid.

The particular value of the exhibition was that it enabled industrialists to see the present state of progress, and to compare directly designs from different countries. Though extremely instructive, many of the inventions shown clearly require much more development before becoming anything like economic possibilities.

Summary of the Technical Papers

It is impossible to describe in full detail the contents of such a large number of papers, but a brief indication is given below of the scope and present state of development in those fields where solar energy could be applied.

House heating. Much can be done by the suitable design of houses to reduce the artificial heat load required, by double-glazed windows and effective heat installation. Additional heat can be provided by collectors of the flat-plate type fixed on the roof with a sufficient hot-water storage to last over two or three days. Several solar-heated houses have been operated in the United States for a number of years, and a newly designed house will shortly be constructed at the Massachusetts Institute of Technology, which should be capable of supplying 80 per cent of the heating requirements throughout the year at Cambridge, Massachusetts.

Water heating. The heating of domestic hot water by solar radiation is a relatively simple process in suitable locations; the problem is to reduce the cost by mass production. Many designs of heater were described, and a large number of simple appliances are in operation in Japan, which has an acute fuel shortage, though the solar radiation conditions are far from ideal. The cheap supply of natural gas in the United States seems to have curtailed the development of solar heaters, even in areas having high solar radiation.

The efficiency of the flat-plate type of collector may be improved by coating the absorbing surface with a thin metallic oxide film which is a good absorber of visible radiation, but a poor emitter of the longer heat waves re-radiated from the collector surface. The researches in this field, described by Dr. H. Tabor, director of the National Physical Laboratory of Israel, created considerable interest at the conference and may have far-reaching consequences by raising the operating temperature of the flat-plate heat collector and extending its use to steam generation.

Water distillation. A simple design of water still for the conversion of brackish to potable water would be a great benefit to isolated farms in arid areas. Considerable development has taken place in the design of such stills in Algiers, Morocco, Australia and California. Here again the essential problem is to produce a design which will be cheap and yet robust. Experiments are being made with the substitution of plastic for glass condensing surfaces. The average rate of distillation is about 0·8 lb. of water per day per square foot of surface area.

Mechanical power. Small power units for irrigation pumping could replace the very inefficient devices, using human or animal power, which are still employed in some parts of the world. Present developments include the Italian design of engine using sulphur dioxide vapour as a working fluid which costs about a thousand dollars per horse-power output. Other possibilities are steam or hot-air cycles, and development of these is proceeding in India, the U.S.S.R. and Israel. Several ingenious designs were described in which the direct action of volatile fluid is used to operate water pumps, but the efficiency of all such devices is necessarily low because of the small temperature difference utilized.

Electrical power. Solar radiation may be converted to electricity by thermo-couples in which heat is an intermediate form of energy and which, therefore, are subject to the toll of the Carnot efficiency. Higher efficiencies are attained by photoelectric devices, and the Bell silicon cell which is now in commercial production attains a conversion efficiency of 11 per cent. The high cost of the cell (25 dollars a square inch) means, however, that at present such applications are very limited; but a battery of such cells is

being used to charge accumulators on telephone systems, and to operate portable radio transmitters and receivers.

Photogalvanic effects. Certain chemical processes are affected by the action of light with a change in the equilibrium. This change may be used to create an electric potential which may be discharged when the products revert to their original state. At the moment such processes are inefficient, but there is the possibility of remarkable developments which may extend the scope of the applications of solar energy. It is possible in a similar manner to produce hydrogen which could be stored and used at any convenient time as a fuel.

Solar furnaces. A number of solar furnaces for the production of very high temperatures have been constructed; the largest at present in use is the well-known 40-ft. diameter mirror at Mt. Louis in the Pyrennees. This was designed by M. Felix Trombe, who announced that construction has now been commenced of a new furnace which will have a capacity of 1,000 kW. There are also large solar furnaces in operation in Algiers, the U.S.S.R. and the United States. At the moment these furnaces are used for research on the properties of materials up to temperatures of 3,000° C.; but they could also be developed for production purposes in suitable localities.

Algae cultivation. Intensive production of algae can be stimulated by the application of solar energy, though the general opinion was expressed that this would only be economically feasible for food production. A suspension of the algae in water, with the addition of nutrients and enrichment of carbon dioxide, is circulated in a suitably designed pond or tank. Although the efficiency of conversion based on the light quanta absorbed for the liberation of one oxygen molecule may approach 30 per cent, the overall efficiency does not exceed 5 per cent in these special cultivation tanks, compared with a figure of well below 1 per cent for the normal growth of crops on land. *Chlorella* is normally used, and there are many biological problems, such as the development of strains which will grow rapidly at temperatures up to 40° C. and will resist diseases or contamination. Considerable development work is in progress in the United States, Japan, the Netherlands and Germany.

Air conditioning, refrigeration and heat pumps. This is a field which is particularly apt for the utilization of solar energy and yet is one where little research work has been described. The problem is to adapt present well-known cycles, such as the absorption process, to operate at the low temperatures attainable by flat-plate collectors. Concentration by mirrors would enable existing cycles to be utilized, but it is generally considered that the expense of such systems would not enable them to compete with fuels as an energy source. Solar heat collectors could be used in temperate climates to improve the performance of heat pumps, if a suitable means of storing the low-temperature heat were available.

Conclusions

Solar radiation is almost the only source of energy that remains unexploited. The total amount of energy available is ample for the world's requirements, and the difficulty lies principally in its relatively low intensity and variability due to the changing position of the Sun and atmospheric effects. The normal energy sources, apart from nuclear energy, are naturally concentrated forms of solar energy—either as fuels which are a concentration in time, or water power which is a concentration in space. So long as these are available, there is little scope for the application of solar energy, mainly because of the high initial cost and the difficulties of energy storage. But there are many places where fuels are expensive or in some cases non-existent, and in such areas there are potential fields of application for solar energy. For example, electrical power could probably be developed from solar energy at a cost of about a shilling a kWh., which would be unacceptable for large communities but would be welcomed if no other source were available.

Artificial collectors of solar energy, namely, all processes except the natural photosynthesis by living plants, comprise essentially the flat-plate type of collector, or concentrating systems with mirrors, or devices which collect photon energy directly. The first method degrades the radiant energy to heat at a low temperature-level; the second system operates at a high temperature-level which can attain half the temperature of the Sun's surface, but is necessarily more complex and needs a guiding system. These systems are satisfactory if the energy is to be used in the form of heat, but in the production of power the inevitable toll of the Carnot cycle results in a low efficiency of operation. If the objective is electrical power, then devices that convert the photons directly into electricity by photovoltaic methods have higher efficiencies and are therefore more promising if the present cost can be reduced by a factor of ten or a hundred. It is along such lines that major developments in the future must inevitably proceed, though, in the meantime, the conventional heat-cycles of low efficiency may bridge the gap.

Applications of solar energy should not be considered as substitutes for existing energy sources but rather as complementary, and the various energy sources should be combined according to the requirements and the resources of the location. Solar energy cannot replace many of the existing uses of concentrated energy, either thermal or nuclear, but can supplement these, especially for the production of heat at relatively low temperature-levels, that is, below the normal boiling point of water. At the moment, solar energy is essentially for nations that 'have not' rather than for those that 'have'; it may enable many of the benefits of industrial civilizations to be attained by those living in isolated and undeveloped areas, by increasing the comfort of life and improving the amenities. In time to come, as fuel reserves are depleted, applications will be extended, and in the future solar energy may contribute greatly to the supply of energy. Considered from these aspects—that is, as an immediate policy for undeveloped areas and as a future policy for other areas—the continuation of research on the utilization of solar energy fulfils an important function in global development.

The Arizona conferences cannot do other than stimulate all these developments; but in addition two definite proposals have emerged from them. The first is the creation of a journal for the publication of solar energy research, and the second is the formation of an applied solar energy research laboratory, possibly in Arizona. Finally, the delegates from outside the United States, numbering more than a hundred, who attended through the generosity of American foundations, will have returned to their own countries with inspiration renewed from these memorable conferences.

Harold Heywood

LARGE-SCALE WEATHER PROCESSES

A SHORT course of three afternoon lectures on "Large-Scale Weather Processes" was given on November 3, 10 and 17 at the Royal Institution, London, by Dr. R. C. Sutcliffe, deputy director (research) of the Meteorological Office. The broad thesis, concerning those parts of the atmosphere, the troposphere and lower stratosphere, which are of primary interest in weather and climate, was first to consider the mean world distributions of temperature and wind as revealed by direct observations, mainly by the methods of radiosonde and radar wind, during very recent years; then to discuss the large-scale day-to-day variations upon this mean state; and finally to review the problem of the general circulation of the atmosphere in the light of these results.

Many serious gaps still remain in the world network of upper-air stations. For climatological purposes the northern hemisphere is tolerably well covered, special credit being due to the combined Canadian–United States efforts in the far Canadian North and to the international Ocean Weather Ship scheme of the Atlantic. The wide stretch of the Pacific is relatively poorly charted, but the tropical land areas have many valuable stations, India being notably progressive, as would be expected from its long tradition in meteorological work. The chains in the southern hemisphere, mainly the efforts of South Africa, Australia and New Zealand, still leave large uncharted areas, and the Antarctic is little known. Much hope is placed upon the coming International Geophysical Year to provide answers to outstanding questions on three-dimensional world climate.

The early ideas on the broad troposphere–stratosphere structure have stood up well to recent observations. The mean level of the tropopause near the equator is at about 100 mb. pressure, about 16 km. high, where the temperature averages about −80° C. with an inversion above continuing to the ozonosphere. In middle latitudes the values are about 250 mb., 10 km. and − 60° C., and approach 280 mb., 9 km. and −50° C. towards the northern pole during summer. During winter the north polar tropopause is often ill defined, and temperatures at these levels fall to lower values. The earlier model, with a continuous sloping tropopause, has, however, been generally abandoned during recent years, the data pointing to a rather sudden break and lowering from 100 to 200 mb. near lat. 30°. There is also frequently, although not everywhere and invariably, another discontinuous descent with increasing latitude in the neighbourhood of the polar front, although this is a region of large day-to-day variations, and in the northern winter the polar front discontinuity in the tropopause tends often to merge with that at low latitudes. The picture for the southern hemisphere is similar so far as data go, but the mean state in high latitudes is largely conjectural; temperatures at equal heights are certainly lower and may average − 60° C. in summer and − 70° C. in winter at the polar tropopause.

The upper-air pressure field can be derived from the surface pressure and the hydrostatic equation, while the equation for the geostrophic wind suffices to give the general pattern of winds except quite near the equator. The limited amount of upper wind data fits well enough into the geostrophic pattern. The most striking features are the jet streams—the more-or-less strong wind maxima reached below the tropopause—and it is now believed that there are two distinct westerly jet streams in each hemisphere associated with the two zones of rapid change or discontinuity in tropopause height. Again, the absence of adequate data makes the picture uncertain, and it is necessary, especially in middle latitudes, to draw the distinction between the climatological mean and the daily synoptic patterns. In the mean the two maxima seem to merge in some longitudes and seasons, whereas the separation can usually be traced on daily charts. The climatological mean maximum wind strength attains a value of 150 knots in certain longitudes in winter, and there seems no doubt that the jet stream structures can, with varying intensity, be traced through all longitudes.

In the study of variability Dr. Sutcliffe confined his attention to middle latitudes. The salient place in theory taken by horizontal wind divergence (in the normal hydrodynamical sense) was stressed by showing its relation with pressure change through the hydrostatic equation; with vertical motion and adiabatic changes through the equation of continuity; and with the development of circulations, cyclonic and anticyclonic, through the vorticity equation applied to quasi-horizontal motions on a rotating Earth. This key part played by divergence would indicate an approach to theory through its direct study; but it is one of the peculiarities of dynamical meteorology that this most interesting quantity is not determinable either from measured winds or geostrophic estimates. A significant divergence for hydrostatic pressure change is less than 1 per cent per day and for vertical motions less than 10 per cent per day. Since winds can be measured, even granted the network, with an accuracy little better than within 10 knots, the divergence over areas of dimensions 100 miles may be directly estimated only within some 10 per cent per hour. The use of the geostrophic wind has long been known to be useless in this respect, as the divergence of momentum vanishes identically, apart from a term due to variation of latitude which is a minor term in dynamical development.

The direct approach through divergence has therefore to be abandoned, at least in extra-tropical latitudes, but the problem has yielded much to an attack resting on the vorticity equation. Vorticity and its changes can be estimated approximately from the geostrophic equation (more recent work aims at using a less-restricted stream function), and the dynamics can be built up from this approach. The simplest, yet still fruitful, attack has come by studying the dynamics of a barotropic atmosphere, virtually non-divergent flow. The justification for meteorological application rests on the smallness of the vertical integral of divergence compared with rates of change of vorticity by advection. In a broad sense the whole troposphere may thus be regarded as moving with a mean field of motion which is almost non-divergent. From this first approximation Rossby derived his now classical barotropic wave equation for idealized zonal flow, which is almost certainly related with the observed long waves of continental dimensions in the circumpolar westerlies.

The two-dimensional solution of the barotropic equation carried out numerically with electronic computing aids and starting with the known initial conditions provides a forecast of the mean flow for twenty-four hours ahead which stands comparison with both the facts and the best efforts of trained forecasters using established methods. Dr. Sutcliffe went on to describe more elaborate dynamical models which take account of divergence and vertical motion and which can therefore handle not only the mean motion but also vertical variations with cyclones and anti-cyclones. It may now be said that a deductive theory of the behaviour of large-scale systems in extra-tropical latitudes can be presented as a straightforward, if still only approximate, development from the hydrodynamical equations. This branch of meteorology has therefore, within the past decade, rather suddenly become almost a matter for formal text-book treatment in the tradition of applied mathematics, and the application of the theory is at present going rapidly ahead towards a new system of forecasting using electronic aids, with the research division of the Meteorological Office at Dunstable making a major contribution. Results so far are definitely encouraging, although in the nature of the physical problem no revolutionary increase in forecasting accuracy can confidently be predicted.

The theory applied to the complex large-amplitude oscillations in the wind flow, coupled with other studies based on perturbation theory, lead to the conception of large-scale instabilities and exponential growth-rates of disturbances as the normal state of the atmosphere, and numerous slides shown by Dr. Sutcliffe, illustrating the surface and upper-air weather maps, made this interpretation seem eminently realistic. The atmosphere is essentially in turbulent motion on the scale of many hundreds of miles, and the evolution of individual turbulent elements is likely to present tremendous, perhaps insuperable, difficulties when the prediction period is extended beyond the time-scale of growth or decay, of the order of one day.

In the final lecture the problem of the general circulation was formulated as that of deriving the mean state and motion of the atmosphere from the basic assumptions of an atmosphere of known composition on the rotating Earth, with land and sea surfaces, subject to solar radiation. At the present time there is no fundamental deductive theory available. Attention was directed to the summer and winter averages of mean-sea-level pressure and the radical differences between them, especially in the northern hemisphere, differences evidently linked with the land and sea distribution and broadly monsoonal in character. This complication is something superposed on a symmetrical planetary circulation, and the first step in a basic theory is naturally to derive the circulation as it would appear on a symmetrical ocean-covered Earth. Evidence, especially from the southern hemisphere, indicates fairly conclusively that the solution must provide for a mean low-pressure belt around the equator, sub-tropical high-pressure belts bounding the easterly trade winds of lower latitudes, broad belts of prevailing unsettled westerlies bounded at high middle latitudes by low mean pressure with relatively high pressure again at the poles, presumably also much disturbed by synoptic systems. Some sort of zonal mean organization is inevitable on a symmetrical Earth, but Dr. Sutcliffe was not prepared to prove that either a smaller or larger number of zones is fundamentally impossible. One must bear in mind that in certain tropical oceans intense cyclones are rather common in low latitudes, and that under rather different conditions the Earth might well have these features regularly, giving two belts of low mean pressure with prevailing westerlies and relatively high pressure at the equator. There is also a frequent, but passing, tendency for a double cyclonic zonal structure to appear in middle and high latitudes. A basic theory should show that the assumed zonal organization is necessary, but perhaps also that an essentially different organization would be found if the values of the fundamental quantities, in particular radiation, were different perhaps only by a little from their present values. Facile qualitative arguments which purport to explain the general circulation are of little value; quantitative treatment is essential.

Pending the development of such basic theory, meteorologists are devoting their attention to the mechanism of the circulation as it is observed and attempting, with some success, to show by what processes the long-term average state is maintained as a balance between losses and gains. Brief attention was given by Dr. Sutcliffe to the water, energy and zonal momentum accounts. Evaporation and precipitation must balance over a relatively short period of time, for the mean world value is about 90 cm. a year, whereas the air contains no more than the equivalent of about 2·5 cm. of water. The patterns are, however, very dissimilar, with precipitation maxima in low and middle latitudes separated by a precipitation minimum which, over the oceans, is an evaporation maximum. The evidence is that the relatively steady trade winds are the vehicle carrying moisture to the equatorial rains, but that the transport to the middle latitude rain areas comes mainly in bursts of moist tropical air (the warm sectors of depressions), separated by bursts of cold dry air moving towards the equator; the transport is then a turbulence phenomenon and not a steady flow in a mean meridional current.

Time prevented a detailed consideration of energy balance during the lecture, but attention was directed to the large amount of energy transported as latent heat and to the less well-known contribution from gravitational potential energy. An inflow of air at high levels coupled with an outflow at low levels could have a major effect in increasing the total energy over an area; the high values of thermal or internal energy over warm anticyclones are really derived from such overturning. The evidence is that a large part of the poleward flux of energy in tropical latitudes which redresses the lack of balance in radiation is carried as gravitational potential energy.

Considerations of zonal angular momentum have received much attention. The long-period balance requires a zero total couple around the polar axis as the result of friction between ground and atmosphere, and this requires a degree of balance between westerly and easterly winds. But taking zones separately, the trade-wind belt with a westward frictional couple exerted on the atmosphere must export westward angular momentum to be returned to the Earth through the friction of the prevailing westerlies. The different zones are thus very closely linked, and one wonders how far forecasting in middle latitudes, which at present takes no explicit account of the trade-wind belt, can be expected to go.

At the present time it is believed that a steady overturning in low latitudes—a meridional convective circulation with ascent near the equator and subsi-

dence towards and in the sub-tropical anticyclones—is an essential link, but that farther northwards the momentum transport (as the moisture transport) is mainly the effect of the unsteady motions, with mean meridional motions playing a minor and perhaps negligible part.

The study of mechanisms, and especially of the relative importance of steady mean circulations and irregular motions, is important if the basic problem is to be formulated in a manner suitable for mathematical attack. It is now thoroughly established that the mean state of the atmosphere cannot be maintained by the mean motions and that the two together do not provide the solution to any real problem. Thus the nature of the turbulence, which is physically different in different zones, must be introduced into the theory at a very early stage: it is not a mere embroidery on a general circulation existing in its own right. It seems probable that the wave-length or scale of unstable synoptic systems which theory shows must develop in the baroclinic atmosphere sets a scale to the zonal mean organization.

The time now seems to be ripe for an attack on the basic problem, and experience with electronic computing for dynamical forecasting in middle latitudes has given to the mere complications of calculating a less formidable appearance. Much progress is almost certain to come during the next decade, and it is urgently required. When one compares the two summers of 1954 and 1955, as experienced in Europe, one is forcibly struck with the fact that the general circulation averaged over a matter of months may run quite differently from one year to the next and so far with no explanation whatever. It seems unlikely that such differences will be understood unless we have a basic theory of the planetary circulation on which to build, and the physical nature of the problem of seasonal weather prediction must for the present remain a mystery.

POPULATION OF BRITISH UNIVERSITIES IN THE 1960's

THE AGE-GROUP BULGE

At the final session, on the afternoon of December 17, of the 1955 Conference of the Universities of Great Britain and Northern Ireland, the problem of "The Age-group Bulge and its Possible Effect on University Policy" was discussed, with Dr. D. W. Logan (principal, University of London) in the chair. In the opening address, Dr. G. E. F. Chilver (Queen's College, Oxford) defined the problem: at the peak of the bulge (1964–67) there will be at least 7,500 more applicants for university places each year; afterwards there will be a plateau, when the number of applicants will be at least 2,500 more than at present. This is calculated simply on the basis of the extra births in the years from 1944. In addition, there has been a trend towards more pupils aged seventeen years and more remaining at school, the increase since 1951 being 30 per cent in England and Wales and 15 per cent in Scotland. If this trend continues, then the numbers of applicants will be larger than the figures given. However, there are good reasons for believing that the trend is unlikely to operate during the peak of the bulge, though it may well be resumed in the later years.

The more important and tractable problem is that of the plateau. The universities should plan for an expansion of the order of 10–15 per cent in the 1960's, concentrated largely in science and technology. The Ministry of Education has provided places in secondary grammar schools to accommodate the extra children during the bulge, and there are signs that enough specialist teachers are coming forward for sixth-form work. The provision of additional university teachers is not so easily envisaged, since they must be found before the extra graduates are forthcoming; this is particularly so in science faculties, where the teachers will need to be withdrawn from other jobs. Capital development, to be in time to make the expansion possible, must take place earlier; it must be provided in the next quinquennium (1957–62). As regards the peak of the bulge, it may be unprofitable to speculate now, provided that planning proceeds for dealing adequately with the level of the plateau.

Exceptional difficulties are to be expected at Oxford and Cambridge, where it is unlikely that the expansion can be large, whatever may be desirable. This is a matter of fact, based on current views in the older universities, and is not a personal opinion. A major factor here is the existing system of college (as opposed to university) finance, the colleges not being directly in receipt of grants from the University Grants Committee. In any event, expansion in a city like Oxford is difficult, population growth being limited and college sites being too small for much further building. It is generally felt that, in view of their structure, colleges are reaching their maximum size. At the peak of the bulge, it is unlikely that Oxford and Cambridge will dilute their tutorial system to the extent tolerated after the Second World War; they are almost bound to raise their entrance standards.

In the second address, Prof. R. G. D. Allen (London School of Economics and Political Science) supported the contention that the problems of the plateau are more important than those of the peak of the bulge. He thought that 2,500 is a low estimate of the extra numbers the universities must soon absorb each year. Certainly a smaller figure would only arise if universities were to impose higher entrance standards or the economic climate in Great Britain deteriorate. The appropriate employment of 2,500 or so extra graduates a year raises special problems, but there can be no doubts about a ready market for scientists and technologists; for arts graduates also, even those with pass or general degrees, there are clear signs that there is an expanding market for their services, for example, in the Civil Service and local government, in banks and insurance offices. The likely recurrent cost of the expansion is not great—£3 million added to grants by the University Grants Committee and £2 million to maintenance awards—but the cost in capital grants is likely to be high and needs to be incurred early, particularly since much of the expansion must be in science and technology.

As regards the peak of the bulge (1964–67), the university population may well rise to more than

105,000, as compared with 50,000 before the Second World War and 80,000 now. The universities cannot easily absorb the peak numbers if they are concentrated heavily in science and technology, nor place them in employment unless they are so concentrated. But elaborate plans are not needed to meet the brief and passing phase of the peak. What is essential is that careful but generous plans should be laid during 1957–62 to provide for a university population at least 10–15 per cent higher than now, rising slowly and steadily during the late 1960's and 1970's as the trend towards more seventeen-year-olds at school operates. Prof. Allen also stressed the importance of maintaining the proportion of women (now about one-quarter) in the university population, and in this he was supported by Dr. C. M. Rigby (University College, London). The risk is that any strain in the universities, and the inevitable concentration on science and technology, will result in smaller numbers of women students.

Lord Simon of Wythenshawe, Prof. J. F. Allen (St. Andrews) and others stressed the extreme urgency of problems created by shortages of scientists and technologists in industry. Large numbers are reported as being trained in the U.S.S.R., and there is a growing scarcity in the United States, where British technologists are already being used. It is essential that in Britain we should not fall behind in the provision of technologists. Lord Simon noted that the universities have been able to achieve a large expansion since the Second World War, and he said that another increase, particularly of university-trained technologists, is now required.

Prof. A. V. Judges (King's College, London) asked the conference not to overlook the human side of the problem. The extra children of the post-war generation have already had a raw deal, through shortages of facilities, equipment and teachers, and they must not be barred from university education. They constitute an asset the country can ill afford to waste. Dr. G. B. Jeffery (director, Institute of Education, University of London) asked whether we are not failing to make best use of our population of university students. Jobs in industry are increasingly requiring a higher level of ability, and we are not turning out enough scientists and technologists even for teaching.

Two vice-chancellors, Sir James Mountford (Liverpool) and Sir Philip Morris (Bristol), expressed very strongly the view that the estimate of an expansion of 10–15 per cent is far too low. They would compound the effect of the higher birth-rate after 1944 with that of the recent trend towards larger sixth-forms in schools, the argument of the opening speakers providing the line from which to deviate—in an upward direction. Unless the estimate is raised, the plans of the universities will be too small, and too slow, to meet the real situation. The urgent need is for a large and immediate increase in capital grants to universities, and in this the Governments of the past decade have failed to provide what had been necessary, and indeed promised, for the expansion since the Second World War. Not only must the deficiency be made up, but there must also be full provision in capital grants for the expansion to come.

R. G. D. Allen

NEWS and VIEWS

Sir Edward B. Poulton, F.R.S. (1856–1943)

The son of an architect, Edward Bagnall Poulton was born at Reading a century ago on January 27, 1856. After taking first-class honours in natural science at Oxford in 1876, he became demonstrator of zoology under George Rolleston. Rolleston's successor, H. N. Moseley, supplied him with material from the *Challenger* Expedition, and in 1883 Poulton published three papers on the tongues of Australian mammals; five years later he discovered that Ornithorhynchus possesses true teeth which cut through the gums, but are replaced by horny plates. His real scientific interest lay in living insects, and he showed "a lifelong delight" in the coloration of animals and in mimicry. During 1884–88 he wrote several papers on the colours of larvæ and pupæ and on the factors influencing their survival value, and these studies led to his election to the Royal Society in 1889; in 1890 he published his classic book, "The Colours of Animals", which placed him in the front rank of protagonists of natural selection. Poulton's early interest in heredity is shown by an article in *Nature* (29, 20; 1883) on the inheritance of abnormal toes in cats. In 1893 he succeeded the first Hope professor of zoology, J. O. Westwood, and he occupied this Oxford chair of entomology for forty years. Recipient of many honours, he was vice-president of the Royal Society (1909–10) and Darwin Medallist (1914), president of the Linnean Society (1912–16) and Linnean Medallist (1922), and president of the second International Entomological Congress (1912). He was knighted in 1935. Poulton was a big man with penetrating blue eyes and a vigorous, friendly personality, and his fondness for making the title of a communication summarize all the contents sorely tried the patience of bibliographers. He died on November 20, 1943, at the age of eighty-seven.

Vice-chancellorship of Hull: Prof. Brynmor Jones

Prof. Brynmor Jones has been elected to be vice-chancellor of the University of Hull as from October next, in succession to Dr. J. H. Nicholson who is retiring. Prof. Brynmor Jones has held the G. F. Grant chair of chemistry in the University College (now University) of Hull since 1947. He has also acted as pro-vice-chancellor of the University since 1954 and prior to that was vice-principal of the College. Prof. Brynmor Jones was at the University College of North Wales prior to proceeding to St. John's College, Cambridge, in 1929. He was thereafter on the staff of the Chemistry Department of the University of Sheffield during 1931–46.

Theoretical Physics in the Australian National University: Prof. K. J. LeCouteur

The development of research in physics in Australia has been greatly strengthened by the appointment of Dr. K. J. LeCouteur to the chair of theoretical physics at the Australian National University, Canberra. Dr. LeCouteur, who at present holds a readership in theoretical physics in the University of Liverpool, has made important contributions to a variety of subjects. In recent years he has developed the theory of the emission of particles from excited nuclei to such an extent that it has become possible

to use the relevant experiments for a quantitative determination of the density of energy-levels of nuclei. While occupied with this work, he has found time to develop quantitatively a method for the extraction of the beam from a cyclotron. This method has led to spectacular success on the Liverpool machine. Earlier in his career, he made interesting contributions to abstract field theory. Dr. LeCouteur's flexibility should be of great value in his new post and should help to start a new school of theoretical physics in Canberra.

Benjamin Franklin's Purse

In connexion with the 250th anniversary of the birth of Benjamin Franklin (1706–90), the Department of Mineralogy of the British Museum (Natural History) is exhibiting the asbestos purse sold by Franklin to Sir Hans Sloane in 1725. The purse came into the collections of the British Museum at the time of its foundation in 1753, on the death of Sir Hans Sloane. It had lain unrecognized for many years and was identified in 1938. On his arrival in Britain, Franklin worked for some time as a compositor and sought to augment his income by the sale of some 'curiosities' which he had brought with him from America. One of these, the asbestos purse, is referred to by Franklin in his autobiography, and also in a letter to Sir Hans Sloane, now preserved in the British Museum. The purse represents perhaps the earliest specimen of asbestos from North America to reach Great Britain.

European Organization for Nuclear Research

At a recent meeting in Geneva of the Council of the European Organization for Nuclear Research, a number of measures were approved. Two of these refer to a scheme of guest professorships whereby prominent workers are invited to spend a year in Geneva helping the research teams there: Prof. G. C. Wick, an Italian physicist at present at the Carnegie Institute of Technology, Pittsburgh, has been nominated for the guest professorship in theoretical physics and will act as leader of the Theoretical Group in Geneva; and Prof. W. K. H. Panofsky, director of the High-Energy Physics Laboratory of Stanford University, California, for the guest professorship in experimental physics. The estimates for the financial year 1956 and the capital investment programme for the period 1952–60 were approved by the Council. The budgetary contributions for 1956 have been fixed at about 34 million Swiss francs as compared with a figure of 25 millions for 1955. This year will be a period of great activity, and will involve a general move to the site at Meyrin, the installation of the laboratories and workshops, and the development of the scientific programme in relation to experiments with the machines. The staff will increase by about 40 per cent. By the end of 1960 the Organization will probably have spent about 197 million Swiss francs. Previous estimates were lower, but unforeseen problems were met in connexion with the stability of the foundations for the proton synchrotron; staff needs have also increased, and by 1960 about five hundred will be required. At the meeting of the Council the following officers were elected: *President*, Sir Ben Lockspeiser (United Kingdom); *Vice-Presidents*, M. Jacques de Bourbon-Busset (France) and Prof. Ivar Waller (Sweden); *Chairman of the Finance Committee*, M. Jean Willems (Belgium); *Additional Members of the Committee of Council*, Dr. Antonio Pennetta (Italy) and Prof. Paul Scherrer (Switzerland).

The Organization is planning to hold a symposium on high-energy physics in Geneva during June 11–23. The first week will be devoted to novel features in the design and techniques of high-energy accelerators, and this will be followed by papers and discussions on special experimental techniques (for example, bubble chambers) and new contributions to π-meson physics. Further information can be obtained from the Organization at Case postale 25, Geneva, 15-Aéroport.

Radiation Monitoring Service in Britain

The National Physical Laboratory radiation monitoring service, started for hospital staffs in 1942 at the request of the Ministry of Health, and extended in the following year to cover industrial workers, has grown steadily to the point where some 50,000 films are issued annually. In 1953 a new organization, the Radiological Protection Service, was set up under the joint auspices of the Ministry of Health and of the Medical Research Council to deal with general aspects of protection against ionizing radiations. This organization has now taken over the N.P.L. service. Initially the service will be operated by the Radiological Protection Service in a similar manner to that adopted by the National Physical Laboratory. The fee will be the same and also the procedure for supplying films and issuing reports. Inquiries should be addressed to the Director of the Service, Mr. W. Binks, at Downs Nursery Hospital, Cotswold Road, Sutton, Surrey (Telephone No. VIGilant 1329). The Service is also prepared to give advice on radiological hazards in general, and on the necessary protection measures for new installations involving such hazards. Future plans include the development of techniques for measuring accumulated radioactivity in the bodies of radiological workers.

U.S. Agricultural Research Institute

At the fourth annual meeting, held during October 17–18 in Washington, D.C., of the Agricultural Research Institute of the United States National Academy of Sciences and the National Research Council, the following officers were installed: *President*, Walter C. Dutton (Dow Chemical Co.); *Vice-President*, Max T. Goebel (E. I. DuPont de Nemours and Co., Inc.); and *Secretary*, Norman F. Kennedy (Corn Industries Research Foundation). The meeting included a paper on the strategy of research, by A. G. Norman, an address on the farmer and the future, by Ervin L. Peterson (U.S. Department of Agriculture), and a symposium on corn in the American economy; the proceedings will be issued shortly. The Agricultural Research Institute is composed of two types of members, those that pay subscription and those that do not, the former being industrial organizations and the latter scientific societies, agricultural experimental stations and Federal agencies. It is designed to foster the promotion of co-operative research that will ensure the best long-term uses of agricultural resources for the national welfare, and for this purpose it is affiliated with the Agricultural Board of the National Academy of Sciences and the National Research Council.

New Zealand Forestry Research

Some reorganization has taken place in forestry research in New Zealand, and the publication of *Forest Research Notes* and of *Forest Products Research*

Notes has now ceased. Their place is being taken by a new series, *New Zealand Forestry Research Notes*, published by the Government Printer, Wellington, which will report research carried out in New Zealand in any field of forestry by all types of worker—public, private, university, etc. The annual report of the Forest Research Institute, Whakarewarewa, will now be issued independently of any research series.

Pinus radiata forms a considerable proportion of the coniferous species constituting the new New Zealand forests and has been the subject of a great deal of research work. No. 1 of *New Zealand Forestry Research Notes* (pp. 72; 1955) treats of combined taper and volume tables for *P. radiata* for 1952 in unthinned stands in the Conservancies of Auckland, Nelson and Canterbury and in thinned stands in the fourth Conservancy of Southland. Technical Paper No. 4 of the Forest Research Institute (pp. 48) deals with some comparative tests with wood preservatives and covers work still incomplete for *P. radiata* that has been carried out in all four Conservancies.

Soil, Vegetation and Land-use Surveys in the Gold Coast

The first of a series of memoirs to be published by the Gold Coast Department of Soil and Land-Use Survey, Kumasi, is a report, with detailed recommendations, on a "Detailed Soil Survey of the Kpong Pilot Irrigation Area" by H. Brammer (pp. 102+9 maps. Accra: Govt. Printer; London: Crown Agents; 1955; 10*s*.). It gives a survey of the irrigation research station on the Accra plains, where experiments are now being carried out to establish, among other things, the most suitable means for irrigating approximately three hundred square miles of tropical black clays. Besides reports on detailed surveys of development areas, this series is to include comprehensive reports and monographs on particular aspects of the systematic soil, vegetation and land-use survey of the country as a whole.

Chemistry Institute at Bogor, Indonesia

Under the Colombo Plan, Mr. H. J. Wood, chemist in charge of the food and drugs section of the Dominion Laboratory, Department of Scientific and Industrial Research, New Zealand, has been loaned for twelve months to the Government of Indonesia and will teach new methods of chemical analysis to the staff of the Chemistry Institute at Bogor. The Institute, which is in the grounds of the well-known botanical gardens at Bogor, covers a wide field of investigation; but its chief interests are the developing of the natural food resources of Indonesia and methods of control for quality—both processing and analytical control. There is a staff of two hundred; but only three of them are qualified chemists. Bogor contains a small European population, and besides the Chemistry Institute there are an agricultural institute and an American plant for the rubber industry.

Measurement of Rate of Dewfall

A paper by Dr. G. Hoffmann, published in *Berichte des Deutschen Wetterdienstes* (3, No. 18; 1955), discusses the thermodynamics of and meteorological conditions for dew formation, and then goes on to describe a novel instrument, invented by Dr. Hoffmann, for measuring directly the rate of dewfall based upon the release of latent heat to the body upon which the dew forms. The rate, of the order of 0·02 mm./hr., needs a very sensitive apparatus for its measurement. The apparatus consists of a series of separate radial sectors, the temperature differences between which can be measured thermoelectrically. One sector is unheated so that dew forms upon it, an adjacent one is heated at a certain rate H and a third sector on the far side of the second from the first at a rate $2H$. The temperature difference between adjacent segments is, in the steady state, proportional to the difference in the rates at which they are being heated, the constant of proportionality depending on wind and temperature. The arrangement gives the rate of dewfall as directly proportional to the ratio of two of the temperature differences. By using a fourth sector of different type of surface, the radiation balance can be measured and the heat conducted from the interior of the apparatus measured from temperature differences to obtain all the terms in the energy balance. A number of curves of rate of dewfall given by the instrument are reproduced, showing rates of dew formation and in some cases subsequent evaporation, amount of dew deduced from the sum of the rates, the radiation balance and the meteorological conditions. The correspondence between the records of dew formation and evaporation and radiation balance is good, but the computed dewfall showed sometimes marked differences from the total dewfall measured by a nearby Leick dew-plate which gives an amount from the volume of dew on the plate, the thermoelectric apparatus apparently giving totals about half those given by the dew-plate. Further improvements of the apparatus to provide an accurate picture of the nocturnal heat balance of the ground surface are envisaged.

International Association for the Exchange of Students for Technical Experience

The continuing success of the scheme launched by the International Association for the Exchange of Students for Technical Experience in 1948 indicates that industry in many countries now appreciates the facilities offered for the general broadening of the outlook of the students taking part in the scheme by means of travel abroad, living and working with the people of other nations and, at the same time, obtaining some useful experience in the industry of another country. In 1955 the number of students taking part in the scheme was 5,153—an increase of 886 over 1954. More interesting is that, while, in 1948, 413 industries were participating in the scheme, in 1955 the number had risen to 2,314. Difficulties about establishing a central committee for the Association in the United States have now been overcome and in September 1955 the American Society of Engineering Education gave an official mandate to the Institute of Education for its sponsorship of the Association in the United States. India and Turkey joined the Association as associate members in January 1955, and it is anticipated that South Africa will join shortly.

Institute of Personnel Management

An examination scheme for new entrants has been launched by the Institute of Personnel Management. The aim of the scheme is to widen the field of recruitment while ensuring that those recruited are suitably qualified for membership. The Institute will not organize any course of study; but students will be free to prepare for the examination by attending evening classes or by private reading. The choice of subjects is wide, so that people with different experi-

ence and knowledge may qualify. It will be difficult, however, for anyone who has not had practical experience in industry or commerce to reach the standard required in the two papers on personnel management and in the oral examination which, with an essay, form the compulsory part of the examination. Various qualified exemptions are allowed. The first examination was held in September 1955 and others will take place at half-yearly intervals.

Bernice P. Bishop Museum, Honolulu : Report for 1954

THE annual report for 1954 of the Bernice P. Bishop Museum, Honolulu, Hawaii (pp. 55 ; 1955), is issued under the attractive title of "Museum at Work". It is an impressive record of activities accomplished under rather isolated conditions and with the usual accompaniment of small staff and limited finance. It naturally concentrates on the presentation of a knowledge of the Pacific area to the public and research for the furtherance of the same policy, and to these ends it has recently installed an exhibit entitled "Insects Close-up", which deals mainly with the control of pests ; another display deals with the Hawaiian house and shows early ways of living. An innovation was Aloka week in the Museum, when a facet of Hawaiian history was presented in an authentic form. Several other special exhibits are described and illustrated. It is an impressive fact that 151 men and women volunteers gave 12,501 hours of their time to work in and for the Museum.

International Mixed Commission on the Ionosphere

THE proceedings of the fourth meeting of the Mixed Commission on the Ionosphere, held in Brussels in August 1954, have recently been published by the International Scientific Radio Union and are obtainable from the General Secretary of the Union at 42 Rue des Minimes, Brussels (pp. 238 ; 300 Belg. fr., £2 3*s*., or 60 dollars). This Commission comprises delegates from the International Scientific Radio Union, the International Union of Geodesy and Geophysics, the International Astronomical Union and the International Union of Pure and Applied Physics. The chairman of the Commission is Sir Edward Appleton, and Dr. W. J. G. Beynon, of University College, Swansea, is the secretary. At the Brussels meeting, which was attended by thirty-one individual delegates, the Commission discussed the ionospheric programme being prepared for the International Geophysical Year ; and also a wide range of papers describing research on the ionosphere and related subjects. Most of the scientific papers presented to the Commission are published in full in the *Proceedings*, together with summaries of the discussions at the individual meetings.

Announcements

PROF. T. G. COWLING, professor of applied mathematics in the University of Leeds, has been awarded the Gold Medal of the Royal Astronomical Society for his distinguished contributions to theoretical astrophysics and particularly for his work on the stability of stars.

PROF. LÉON BINET, professor of physiology in the University of Paris, has been elected vice-president for 1956 of the Paris Academy of Sciences.

MR. I. C. MCDOWALL, chief executive officer of the New Zealand Pottery and Ceramics Research Association (Inc.), has been appointed director of the Association. Mr. McDowall, who graduated from Victoria University College, Wellington, in 1944, has been on the staff of the Association since its formation in 1946.

DR. W. D'A. MAYCOCK, a member of the scientific staff of the Lister Institute of Preventive Medicine, has been given the 1955 award of £50 of the Oliver Memorial Fund for his contributions to the development of blood transfusion. Dr. Maycock is adviser in blood transfusion to the Ministry of Health and honorary consultant in blood transfusion to the War Office.

AS in previous years, the British Association will rent tables during 1956 at the Marine Biological Station, Plymouth ; the Freshwater Biological Station, Windermere ; and the Zoological Station, Naples. Research workers wishing to use these facilities should write to the Secretary, British Association, Burlington House, London, W.1, giving their qualifications, the work intended and the dates required. Applicants should normally be members of the Association.

THE Food Group and the Oils and Fats Group of the Society of Chemical Industry are holding a conference on "Recent Advances in the Knowledge and Uses of Phospholipids in Foods", which will take place at the Wellcome Research Institute, 183 Euston Road, London, N.W.1, during February 9–10. The registration fee for the conference is 5*s*. for members of the Society and £1 for non-members. Registration forms, to be completed by February 6, and further information, can be obtained from the Assistant Secretary, Society of Chemical Industry, 56 Victoria Street, London, S.W.1.

THE Textile Group of Aslib, in co-operation with the Textile Institute, is organizing a conference on "Textile Information—Uses and Needs", which will be held at the Textile Institute, Manchester, on March 9. The objects will be to direct attention to the need for establishing and maintaining channels for the flow of technical and economic information to units and individuals in the industry best able to make use of it ; to indicate methods by which the communication of ideas and information might be most effectively achieved ; and to renew existing sources of textile information. Further information can be obtained from the Textile Institute, 10 Blackfriars Street, Manchester 3.

THE Cortina-Ulisse European Prize of one million lire (about £570), which is awarded by the magazine *Ulisse*, is being offered this year for a work on the history of labour organizations during the past century up to the First World War from scientific points of view. Only original works printed for the first time in Europe during the past five years will be eligible, and five copies should be sent in, before February 28, either by the author or by the publisher, to the Editor of *Ulisse*, Sezione Premio Europeo Cortina Ulisse, Corso d'Italia 43, Rome.

A MEMORIAL service for the late Sir Richard Redmayne will be held at 12.30 p.m. on January 26 at St. Margaret, Westminster. The service, which will be conducted by Dr. E. G. Jay, chaplain to the Archbishop of Canterbury, has been arranged jointly by the Institutions of Civil Engineers, of Mining and Metallurgy, and of Professional Civil Servants.

EUROPEAN ASSOCIATION OF EXPLORATION GEOPHYSICISTS

MEETING IN LONDON

THE European Association of Exploration Geophysicists has grown rapidly since its foundation in 1951 and now has a membership of more than a thousand, which is still increasing by about two hundred a year. For its ninth meeting the Association met in London at Church House, Westminster, during December 7–9, the distribution by countries of those attending the meeting being as follows: Great Britain, 123; France, 37; Germany, 22; United States, 13; Netherlands, 8; Italy and Yugoslavia, 4 each; Denmark, 3; Belgium, South Africa and Sweden, 2 each; Algeria, Austria, Canada, Eire, Japan, Norway, Spain and Switzerland, 1 each; total, 228. As these figures indicate, the Association takes a very elastic view of its territorial limitations, but the various members are united in their interest in applying the discoveries of physics to the exploration of the Earth's crust and its mineral resources.

The technical meeting was opened by Sir Edward Bullard, then director of the National Physical Laboratory, Teddington, who reviewed recent progress from the point of view of a geophysicist who has just renewed his interest in geophysics after several years in the field of 'un-prefixed' physics. He confessed to having been rather disappointed at the lack of any spectacular progress in geophysical methods during these years. At the same time, he directed attention to the many directions in which progress has been made, and where important developments may be imminent. This theme was taken up again later with more detailed treatment by Dr. R. G. Van Nostrand, who read a paper prepared in collaboration with Milton B. Dobrin on "Current U.S. Developments in Exploration Geophysics". Dr. Van Nostrand disagreed with Sir Edward, and expressed the view that important advances have already been made and are being vigorously applied in the field. He selected as most noteworthy the techniques of magnetic recording and velocity logging, both of which are rapidly entering everyday use in oil prospecting in the United States.

As pointed out by Sir Edward Bullard, the application of magnetic recording techniques to seismic exploration work has been facilitated by the developments demanded by guided-weapon research. The latter is now benefiting in turn by a wider market for high-quality recording apparatus. The advantages of making seismic records magnetically rather than photographically derive from the flexibility introduced by being able to reproduce the information again as electrical impulses. Then varying filters may be applied, or more novel methods under development, to improve the signal-to-noise ratio; time delays may be introduced by automatic correction techniques in order to facilitate interpretation; and lastly, and perhaps most important, the information can be conveniently stored against the day when better interpretation methods allow one to make the fullest use of the recordings, without having to re-shoot in areas which are often exceedingly difficult of access.

The continuous velocity logging of boreholes, continued Dr. Van Nostrand, offers not only greater convenience and speed than the conventional well-shooting, but also, by measuring the seismic velocity through much thinner layers, it gives the variations in velocity in much finer detail. The study of these continuous velocity logs in conjunction with seismic reflexion records shot from the surface is leading to a better understanding of the origin of reflexions. This in turn can lead to better resolution in complex geological situations, and may even afford a solution in some cases for the most challenging problem of present-day oil-finding, namely, the detection of stratigraphic trap reservoirs.

Although recent research in petroleum geophysics has been mainly concentrated on seismic techniques, Dr. Van Nostrand dealt also with several important developments in the application of other geophysical methods to mining exploration and to civil engineering problems. New borehole logging techniques have been applied to the search for uranium, an induced electrical polarization method has been successful in finding ground water, airborne electromagnetic methods have been widely used in the search for base metals in Canada, and a new airborne magnetometer has appeared, which is especially adaptable for use in light aircraft. Also, high-frequency seismic reflexion equipment has now been developed which offers hope for the successful application of reflexion seismology to mining geophysics and other problems involving structure at shallow depths.

The principles of the new airborne magnetometer were dealt with at greater length by G. Phillips and G. S. Waters, of the Signals Research and Development Establishment, Ministry of Supply. They have independently developed an apparatus, similar to that now in use in the United States, for measuring the magnitude of the total geomagnetic field from the frequency of precession of the protons in water around the field. (For a brief account of this work, see *Nature*, October 8, p. 691.) The advantages of this equipment for airborne magnetometer-surveying derive from light weight and simplicity, occasioned mainly by the fact that, unlike the flux-gate type of magnetometer, precise orientation in relation to the direction of the total field is not essential, so that sensitive servo-systems for this purpose are not required. Another advantage lies in freedom from instrumental drift.

The high-frequency seismic reflexion system was also given more detailed treatment at the meeting, its application and future possibilities being the subject of a paper by Curtis H. Johnson. Whereas reflexion equipment in common use at present employs frequencies in the range 30–60 c./s., the new equipment makes use of frequencies of the order 70–200 c./s. By this means the power of resolution is increased, at the expense, of course, of some increase in attenuation within the Earth. By using a faster recording speed and rapid automatic gain control, reflexion as early as 0·025 sec. after the shot can be satisfactorily timed, so that reflecting horizons as shallow as 100 ft. can be mapped. Besides its usefulness for the shallower problems of geophysics outside the petroleum industry, there are circumstances where high-resolution equipment can help the petroleum geophysicist. In areas where deep weathering or drift presents difficult low-velocity-layer correction problems, the reflexion times down to a known shallow marker-bed will give the necessary corrections for the deeper horizons. Other areas seem to be particularly favourable for high-frequency reflexions, so that more reflexions, and greater

resolution between adjacent reflexions, can be obtained even at depths down to 5,000–6,000 ft.

A paper on instrumental distortion and the seismic record, by N. A. Anstey, attracted considerable interest. Taking a standard seismic input pulse—the Ricker velocity wavelet—Anstey has determined the various distortions of this pulse which arise due to filtering, automatic gain control, and high-amplitude effects in reflexion amplifiers. These distortions may affect the relative amplitudes, the shapes of the pulses, and the arrival times. Clearly, in the attempts which are now being made to use the reflexion method to the utmost limits of its resolving power, these instrumental effects must be fully understood, and in this respect Anstey's work is a most valuable contribution.

Out of the remaining twenty-three papers presented at the meeting, almost half dealt with the detailed mathematical and geometrical problems involved in the interpretation of geophysical results. Of these, the papers by F. Veyretout, M. Rimbaut, and by J. Schoeffler and L. N. Nardon were concerned with seismic reflexion problems; those by L. H. Tarrant and by S. Wyrobek dealt with refraction interpretation; those by A. H. Kleijn and by K. Helbig investigated the effects of seismic anisotropy; while A. Lundbak, C. Monnet, A. Hahn and T. Knight gave papers on gravity and/or magnetic interpretation.

Considerable interest was attracted by three papers presenting the results of gravity determinations: the first, by F. A. Vening Meinesz and A. P. Collette, reported a regional gravity survey of the North Sea carried out by means of an underwater gravity-meter, with the co-operation of the Royal Netherlands Navy; another, by G. P. Woollard, W. E. Bonini and J. C. Rose, gave the latest results in their programme for the establishment of a world-wide network of gravity bases; and the third, by Rose and Woollard, described the measurements carried out from end to end of the North American continent with quartz gravity pendulums, with the object of establishing a gravity calibration baseline. Three papers dealt with seismic field-research: two of these, by T. Gaskell and by M. Pieuchet and H. Richard, were concerned with the efficiency of the customary source, that is, explosives either in a shot-hole or on the surface; and in the other, R. G. Mason described investigations of surface waves near the less commonly used alternative source, namely, a dropped weight. Actual field-surveys for mineral resources were the subject of two papers, one by M. Guerrier and A. Rogier on the Lorraine coal-basin, and one by R. Cassinis on exploration for sulphur limestone in Sicily.

The remaining four papers serve to illustrate the diversity of topics at the meeting. W. Domzalski dealt with problems of very shallow refraction work for civil and mining engineering purposes. F. Sumi treated some of the refinements of the electrical earth-resistivity method. Some novel ideas on the possible turning to advantage of seismic noise in prospecting were expounded by M. Matschinski. Lastly, very precise hydrostatic levelling for foundation problems was described by O. Meisser.

The meeting ended with a showing of the British Petroleum Company's film, "The New Explorers". Despite the many counter-attractions of London, attendance at the technical meetings was consistently high, showing that the meeting was most successful in furthering the interchange of geophysical knowledge and ideas.

L. H. TARRANT

STRUCTURE OF SEMI- AND NON-CRYSTALLINE MATERIALS

THE autumn conference of the X-ray Analysis Group of the Institute of Physics was held in London at the Institution of Civil Engineers during November 18–19, the topic for discussion being "Semi- and Non-Crystalline Materials". In her opening paper, on the mechanism of crystallite growth in carbons, Dr. R. E. Franklin reviewed her work on the structure of graphitic and non-graphitic carbons. The latter can be further classified into graphitizing and non-graphitizing carbons according to whether crystallite growth can be induced by heat-treatment or not. From this fact, and from the nature of order produced during growth, certain conclusions about the mechanism of crystallite growth can be drawn, in particular when the graphitic sheets grow by the addition of edge groups and when growth is normal to the plane of the sheets. In discussing this paper, Dr. G. E. Bacon described his own work on radiation damage in crystalline graphite, where the order destroyed by irradiation can be completely restored by heat-treatment.

Dr. R. Diamond gave an account of a new theoretical method which he has developed for the interpretation of amorphous scattering curves, and which he has applied to the composition of various coals. Exact theoretical curves for the X-ray scattering from perfect condensed aromatic ring systems of various sizes were first calculated on the EDSAC digital computer. A linear combination of such curves was then fitted to each of the observed experimental intensity curves by the method of least squares, and from the coefficients in the combination histograms were obtained showing the proportions of the various ring systems present. This matrix method is to some extent analogous to the process of Fourier inversion; in cases such as this one, where all the possibly existing components are known, it avoids the difficulties due to cut-off and to the inaccuracies in the experimental curves at high values of $(\sin\theta)/\lambda$. The method has been applied by Dr. Diamond to a study of vacuum carbonization of coal, where the effects of polymerization and evaporation have been clearly shown. Dr. L. Cartz has used the same method on the vitrain series of coals and on ethylene diamine extracts of coals, and has derived histograms of molecular sizes, matching being carried out in the region of the (11) band. Discrepancies occurring between theoretical and experimental curves in the region of the (10) band can be explained as due to the (00*l*), that is, to intermolecular effects. Replying to questions by Dr. Stadler, Drs. Diamond and Cartz stated that they have also examined quinone extracts in which experimental and calculated curves do not agree; a chemical change during extraction is thought to have taken place.

Prof. R. W. Douglas reviewed some of the experimental work on the structure and physical properties of glass. The principal X-ray work in the subject, that of Warren and his associates on silica, and on soda-silica and boric oxide glasses has led to a concept of network-forming atoms and network-modifying atoms. The rather anomalous physical properties of boric oxide and sodium borate glasses have to some extent been explained by recent infra-red absorption measurements on these materials which have given important information on the bonds present. The

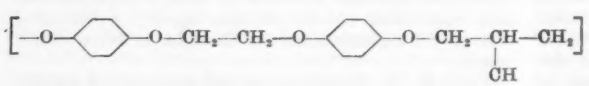
X-ray results have indicated the liquid-like structure of glasses, and, on the whole, their behaviour fits well into this pattern; much research, however, is still needed into the long-range order of glasses.

Dr. R. L. Gordon described X-ray measurements made by himself and his colleagues which indicate the presence of a disturbed layer, effectively about 1000 A. thick, existing at the surface of finely ground quartz particles which could be partly removed by etching, particles of diameter less than about 0·5μ apparently not containing any perfectly crystalline material. This conclusion was not universally accepted in the subsequent discussion, which, however, failed to produce an alternative explanation of Dr. Gordon's X-ray results; these were supported by other measurements such as differential thermal analyses. In discussing the papers on glasses and on quartz, Dr. A. E. J. Vickers described the difficulty of producing commercially truly isotropic fused silica.

Dr. W. May next gave an account of special X-ray diffraction techniques developed for obtaining patterns of liquid systems. His apparatus consists of a cylindrical powder-camera on the axis of which a free jet of liquid serves as specimen. The camera is kept filled with helium so that the pattern is practically free of unwanted scattering. The liquid is circulated by a pumping unit of the 'closed' type needing little attention, and interlocking safety devices between the X-ray unit and the pumping unit safeguard the operation of both. Provision has been made for working temperatures between 0° C. and 80° C.

Mme. J. Longuet-Escard described the work which she has carried out with J. Mering on colloidal nickel hydroxide. In settling from a fresh suspension, very small crystals of nickel hydroxide tend to stick together by their (001) faces. In this coagulation the ionic double layer of the surface is imprisoned, and non-rational (00*l*) reflexions are produced. The abnormal spacing (that is, the thickness of the imprisoned ionic layer) cannot be calculated from Hendricks's and Teller's formula, since its distribution in the stacking process does not follow a law of constant probability. The spacing can be determined directly by a Fourier transformation of the (00*l*) intensity distribution. The thicknesses thus measured were found to depend upon the nature of the anion and the state of hydration of the double layer. In the case of a chloride ion, spacings more than three times the normal spacing of nickel hydroxide (4·60 A.) have been found.

The final session of the conference was devoted to a discussion of non-biological fibres. Dr. L. Brown described preliminary crystallographic investigations on a polymer of repeating unit:



which may be prepared from 4,4′-dihydroxydiphenoxyethane and epichlorhydrin in the presence of sodium hydroxide. In the crystal the molecule is found to be twisted, probably S-shaped with the planes of the benzene rings at an angle to the chain axis. The crystallographic repeat is probably two molecular units, arranged around a two-fold screw axis. The symmetry is monoclinic with two chains (that is, four residues) in the unit cell. The interesting point about this structure is that the *b* (chain) axis extends reversibly from 27·6 A. to 29 A. on stretching, with only slight changes occurring in the diffraction pattern. Under suitable conditions the molecules may be drawn out to a straight form with a repeat of 16 or 32 A., but they do not appear capable of crystallizing in this form.

Dr. E. R. Howells next presented the results of X-ray examinations carried out by Mr. C. W. Bunn and himself on straight-chain fluorocarbons, particularly on 'Fluon', polytetrafluoroethylene. The fluorocarbon chains, both in 'Fluon' and in perfluorocetane, $C_{16}F_{34}$, were found to have a helical configuration with six turns in the repeat unit of thirteen (CF_2) groups. On account of the relatively large van der Waals radius of 2·7 A. of fluorine, the cross-section of the fluorocarbon chain is very nearly circular, and it should therefore be easy for chain segments to rotate about their own axes. This rotation probably accounts for the remarkable room-temperature transition which occurs in 'Fluon' some 300 deg. below the melting point; as Mr. Bunn pointed out in a reply to a question, the rotation may also be the explanation of the remarkably low coefficient of friction of the polymer: the cylindrical molecules may be acting as roller bearings.

Dr. A. Keller has been studying orientation phenomena in synthetic crystalline polymers, where the crystallites do not appear in a haphazard way, but form sub-microscopic fibrous aggregates. These fibrils themselves can build up larger structures, the spherulites, within which they are essentially radially disposed. Thus a polymer which is macroscopically unoriented is in fact composed of minute oriented regions which arise spontaneously from melt or solution. Dr. Keller has studied the orientation of the unit cell within these regions by means of a micro X-ray technique and found it to be such as to result in a predominantly perpendicular disposition of the chains with respect to the radii of the spherulites. In certain special cases the X-ray results have been correlated with birefringence measurements. The existence of these spontaneously oriented regions can manifest itself when a crystalline or crystallizing polymer is artificially oriented. A number of uniaxial orientations were observed which are unusual since the molecular chains are oriented preferentially in directions other than that of the external orienting influence. While this is unexpected from simple molecular considerations, Dr. Keller showed that the anomaly is only apparent and that the actual orientations fit in well with his picture. Prof. J. D. Bernal pointed to a possible similarity between Dr. Keller's spherulites and those observed, although of a much larger size, by Dr. Conmar Robinson in solutions of synthetic poly-γ-benzyl-L-glutamate.

In a short contribution, Dr. K. Dornberger-Schiff gave examples of the type of misalignment and 'mistakes' occurring in semi-crystalline material in which only a two-dimensional periodicity is retained. Such structures are best treated by considering the planar symmetry of the two-dimensionally ordered regions rather than by space-group theory. Important examples of the type of treatment suggested by her are afforded by certain fibrous minerals, notably chrysolite, halloysite and garnierite, which Dr. E. J. W. Whittaker has been examining. He has found that, while these minerals do not possess crystal lattices of the ordinary kind, their structures can be described in terms of cylindrical lattices. He defined a cylin-

drical lattice as a set of congruent two-dimensional lattices inscribed on a set of cylindrically curved surfaces and mutually ordered with respect to the cylinder axis, there being equal and uniform normal spacings between each successive pair of such surfaces; he then developed a classification of such lattices which is a cylindrical analogue of ordinary space-group theory.

Dr. D. E. Corbridge reported on his structure analysis of the fibrous 'Kurrol' salts, which are long-chain metaphosphates; they are insoluble and exhibit colloidal behaviour. In the case of rubidium metaphosphate, the unit cell is monoclinic and contains continuous chains of composition $(PO_3)_n^{n(-)}$ spiralling around the screw axes with a repeat pattern every two PO_3 units; similar structures have been found for the potassium and cæsium salts. Dr. Corbridge pointed out some interesting structural resemblances between the metaphosphate chain and long-chain anions found in certain silicate minerals which also form helical structures.

An interesting and stimulating evening discourse was delivered during the conference by Prof. A. R. Ubbelohde, whose subject was "Crystallography and the Phase Rule". The next conference of the Group will be held jointly with the Low Temperature Group of the Physical Society; it will take place in Oxford during April 11–13 and will be devoted to low-temperature crystallography.

U. W. ARNDT

DENSITY OF THE LUNAR ATMOSPHERE

SOME of the values of the density of the Moon's atmosphere obtained by observers in the U.S.S.R. are discussed by E. J. Öpik, of the Observatory, Armagh, in a paper in the *Irish Astronomical Journal* (3; March 1955). The Russian workers determined the relative polarization of the diffuse light of the sky near the horns of the lunar crescent and they arrived at a value approximately $0{\cdot}5 \times 10^{-4}$ of the terrestrial atmosphere, but A. Dollfus in 1952 found a value 10^{-9} for the upper limit (*C.R. Acad. Sci., Paris*, 234, 2046; 1952). J. N. Lipskij carried out a detailed investigation and arrived at a value of the order 10^{-4} (*Pub. Sternberg Astro. Inst., Moscow*, 22, 66; 1953), but Öpik's examination of the matter shows that the values obtained by the Russian observers must be far too big.

In his investigations, Öpik completely ignores any possible absorption by the hypothetical lunar atmosphere, which is too thin to cause absorption effects, and hence the surface brightness in a given direction will be proportional to the intensity of illumination and to the illuminated air mass per unit cross-section along the line of sight. On this assumption, he shows that the surface brightness of the earth-shine at quarter phase is at least thirteen times as great as that of a vertical column of the lunar atmosphere illuminated by the Sun, and this result is used to determine the upper limit to the mass of the lunar atmosphere. It seems highly probable that any lunar atmosphere (if such exists) will be practically free of dust, and Raleigh scattering of light by the gas molecules prevails. It is assumed that the scattering power of the lunar atmosphere is about the same as that over high mountain tops, such as Mount Whitney (4,420 m. above sea-level), and C. G. Abbot's observations on Mount Whitney (*Ann. Astrophys. Smithsonian Inst.*, 3, 145; 1913) showed that the surface brightness of a sunlit atmosphere at sea-level, but of a degree of purity equal to that on Mount Whitney, is $8{\cdot}02 \times 10^{-7}$. The surface brightness of the earth-shine, measured by Öpik in 1924 and by Danjon in 1936, is about 25·84 mag., from which it is easily found that the surface brightness of earth-shine is $4{\cdot}61 \times 10^{-11}$. The ratio of the lunar to the terrestrial atmospheric masses in vertical columns of unit cross-section is therefore less than $4{\cdot}61 \times 10^{-11}/13 \times 8{\cdot}02 \times 10^{-7}$—that is, less than $4{\cdot}42 \times 10^{-6}$—making use of Öpik's figure thirteen, as already explained earlier.

It appears from this investigation that the mass of the lunar atmosphere is less than 1/226,000 of the terrestrial, and with the smaller gravity on the Moon, the pressure and density of the lunar atmosphere cannot be more than one part in 1·3 millions of those of the terrestrial atmosphere.

INSECTICIDES AND THE BALANCE OF ANIMAL POPULATIONS

DR. H. E. HINTON, of the Zoology Department, University of Bristol, has recently directed attention to the dangers involved in the indiscriminate use of insecticides (*Sci. Prog.*, 43, No. 192; October 1955).

Much has been written on the kinds of direct injury that can be done to crops and other useful plants by insecticides, while individuals using poisons are materially concerned with any damage they may do to farm animals, crops and ornamental plants. They are not always as interested in the damage they may do to wild animals and birds, and they occasionally tend to dismiss injuries to their operatives as unavoidable occupational hazards. For example, in Argentina the incidence of dermatitis in workers exposed to BHC was once as high as 25 per cent. Fish are said to be as sensitive to DDT as insects; but the possibility of producing damaging concentrations in water as the result of normal control operations is slight.

In 1952 many instances of death or serious injury following the use of DDT, BHC and other chlorinated hydrocarbons had been reported. The chlorinated compounds which are fat-soluble and chemically stable tend to accumulate in the fatty tissue; this explains why animals with a large amount of fat tend to be less susceptible to acute poisoning than under-nourished ones. It has been shown that, in mammals, accumulation occurs at all ordinary levels of intake, and rats may accumulate DDT in the fat body until there may be as much as thirty times the level of intake. More DDT may accumulate in the fat body than is required for a lethal intravenous dose without the mammal showing any obvious signs of poisoning. Elimination occurs slowly; but sudden starvation may release enough DDT to affect the animal seriously. It is also known that there are great seasonal differences in the susceptibility of insects to chlorinated compounds, and there is good evidence that these seasonal differences are related to the amount of depot fat present. Many investigators believe DDT should not be used on dairy cattle and animals that are to be eaten because it accumulates in the milk and fatty tissues.

THE SECOND ENTOMOLOGICAL EXPEDITION TO THE HIMALAYAS

By Prof. M. S. MANI
School of Entomology, St. John's College, Agra

DURING May–June 1955 I led the Second Entomology Expedition to Lahoul-Spiti in the North-West (Punjab) Himalayas. There were a team of seven members and more than a ton of equipment and supplies of food. The University of Agra made a small grant towards a part of the expenses of the Expedition. Leaving Agra on May 18, we reached Manali at the end of the Beas Valley. Owing to unexpected and unusually late snow-fall, we were greatly delayed and held up for several days at about 9,000 ft. Our original plan of establishing a supply base at about 15,000 ft. on Kanzam La in the Spiti border had to be abandoned. The base camp was established a little below 13,000 ft. in a meadow opposite the Kulti Nal glaciers. After overcoming numerous difficulties and considerable delays, some essential supplies were pushed to an advance base camp below the Great Ice Fall Mountains of the Purana Khoksar Nal. Although not specially organized for spectacular peak-climbing, the Expedition climbed several unnamed and unclimbed peaks in search of high-altitude insect life.

Although the climbing programme had to be greatly curtailed owing to continued bad weather, more than five thousand specimens were brought back, some of them being taken at altitudes never before reached by an entomologist in this part of the Himalayas. We also studied the various conditions under which the high-altitude insect life flourishes and made observations on the habits and peculiarities of life-cycles. Several hundred close-ups in 'Kodachrome' and black-and-white were also made of the high-altitude flowers and insects in their natural surroundings with the help of a 'Leica' camera and its accessories.

The collections, which will ultimately be deposited with the Zoological Survey of India, are now being sorted out and card-indexed. Nearly every specimen has been microfilmed. The identification of the material, descriptions of the new forms and detailed reports of the Expedition's findings will not be ready for some time. I may, however, direct attention to certain interesting features of the high-altitude insect life of the Himalayas.

Although the variety and abundance of insect life as a whole rapidly fall off beyond the limits of tree-growth, the zone of permanent snows immediately above these limits is by no means barren. On the permanent snow at altitudes rarely ever reached by ordinary human beings, there habitually live a remarkable variety of insects. They thrive well under conditions of glare (great radiation especially in the ultra-violet part), intense cosmic-ray activity, reduced pressure, great oxygen deficiency, constant fierce cold dry winds, frequent avalanches and snowstorms, absence of plant life, relative scarcity and lack of variety of food and restriction of the feeding period to the very brief summer, etc. Dry barren rock that often gets heated to an uncomfortable degree in the summer sun even at great elevations, damp moss-covered stones, snow-fields, glaciers, glacial torrents, cracks and crevices in rock, caves and other spots have each their characteristic insect inhabitants.

While nearly every order of insects with which we are familiar in the plains also occurs at high altitudes, the species are different in almost all cases. The high-altitude insects of the Himalayas superficially resemble the alpine type; but actually they show closer affinities to the Tibetan and Central Asian faunal elements rather than to European. There are also sufficient indications to believe that the insects of this region represent, at least partly, a geographical relict of the Pleistocene life of Central Asia. Deep infiltrations of the subtropical and often also of the tropical faunal elements may be detected as high as 10,000 ft. above the mean sea-level.

Among the high-altitude insects of the Himalayas, Collembola, Diptera, Coleoptera, Dermaptera, Plecoptera and Ephemerida (given in order of abundance) stand foremost. Between 8,000 and 14,000 ft., Plecoptera, Ephemerida and Trichoptera are dominant types, especially in the glacial torrents. Some of these ascend right up to the edge of the permanent snow. Remarkably enough, the insect population of all kinds is far more dense in the glacial torrents than in stagnant waters. This concentration in the torrents is perhaps due to the more uniform though lower temperatures of the torrents than in the still waters. From 12,000 ft. upwards we come across Dermaptera–Coleoptera associations, and beyond 15,000 ft. above sea-level Collembola, Coleoptera and Diptera replace the Dermaptera–Coleoptera complex. The last-mentioned three orders seem to have successfully taken up permanent abode at much higher altitudes than any other insect and also occur at greater elevations than 15,000 ft. Collembola are perhaps the only forms which may be found as high as 18,000 ft.

In addition to the species that occur habitually at great altitudes, the Expedition came across great swarms of migrating Lepidoptera. *Colias ladakensis* and *Argynnis claudi* were taken at about 17,000 ft. on snow-fields. Upper-air currents and the afternoon winds blow up millions of minute insects like aphids, fruitflies and even larger forms like noctuid moths from the plains of India on to snow-fields and glaciers between 14,000 and 17,000 ft., especially on the southern aspect.

A most remarkable variety of adaptations can be correlated to the peculiar conditions of life. Widely unrelated groups occurring on exposed boulders, in glacial torrents and on wind-blown snow-fields and glaciers exhibit considerable adaptive convergence in the development of devices for securing firm anchorage. The great majority of the truly high-altitude insects show extremely low tolerance of even slight increase in temperature, due undoubtedly to long acclimatization to the generally sub-zero temperatures. Some of them are capable of surviving under 30 ft. of snow for several months without apparent harm.

A striking feature of the high-altitude insects of the Himalayas is the greatly prolonged larval life, with hibernation and diapause often extending to one or even two years. The adult is extremely short-lived. We came across a great number of forms still hibernating towards the end of June under stones covered by several feet of snow. *Calosoma madeirae kashmirense* is, for example, a common carabid beetle that was hibernating in this way at about 13,000 ft. On an enormous glacier at about 14,000 ft. on the Dhauladhar I found on a previous occasion a mass assemblage of hibernating adults of Coccinellids. At

relatively lower altitudes just beneath the permanent snow line, with the advance of summer and the gradual melting of the snow, the scene becomes one of a mad race of different species against time. The noon-day sky with the air 4° below zero becomes filled with gigantic swarms of may-flies, stone-flies, caddis-flies, butterflies, gnats and various other insects which mate, lay eggs and perish before the same evening. The few that survive may be destroyed in a blizzard the next afternoon. Unlike polar forms, most of the high-altitude insects here are heavily pigmented as a protection against the glare and ultra-violet radiation. This may also be the result of crowding during development in sheltered spots. While only a small fraction of them thrive on lichen, moss or algal slimes, the great majority of the species are either scavengers or carrion feeders or devour each other. As one goes higher and higher the increasing proportion of the carnivorous species can be recognized, until at altitudes above 15,000 ft. they are the only types that occur permanently. The wind-borne organic matter already referred to also contributes to the food resources of the high-altitude insect life.

A MODIFIED METHOD OF TWO-DIMENSIONAL ZONE ELECTROPHORESIS APPLIED TO MUCOPROTEINS IN SERUM AND URINE

By R. L. MARKHAM

Department of Rheumatology, Royal Free Hospital, London

DURRUM[1] has described a technique of two-dimensional zone electrophoresis on paper in which the analysis in the first buffer is transferred on a strip of paper to the surface of a sheet of paper soaked in the second buffer. The strip is placed in such a position that the substances on it migrate in a direction at right angles to that in the first buffer. We wished to use two-dimensional electrophoresis to obtain direct confirmation of the positions of serum mucoprotein fractions in the serum protein pattern obtained by electrophoresis at *p*H 8·6. Two serum mucoprotein fractions may be isolated from all other serum proteins by electrophoresis at *p*H's between 4·4 and 4·6[2] (Fig. 1). Since in the latter technique filter paper is sandwiched between glass plates, the following modification of Durrum's method was developed.

Instead of placing the strip on the surface of the paper, a slot to receive it of corresponding width and slightly greater length was cut in the centre of the second sheet at right angles to the direction of the second separation. The strip was partially dried at room temperature before being placed in position. The edges of the two pieces of paper were then carefully teased together, except at either end of the strip where a gap was left. The sheet of paper had been soaked in buffer, blotted, and placed on the lower glass plate before receiving the strip, and the flow of the new buffer into the strip concentrated the material in it as a narrow band along its centre. The absence of buffer flow inwards at either end of the strip prevented disturbance of spatial distribution along it. The upper sheet of glass was then placed over the paper, the second electrophoresis carried out after a short period of equilibration, and the paper—minus the strip—was then stained. The results obtained are shown in Fig. 2 (*A*). The occurrence of *M*-1 and *M*-2 in the α_1- and α_2-globulin positions respectively is clearly indicated. The *p*H of the second buffer is chosen to ensure that the fractions to be studied are carried clear of the transferred strip. With other combinations of buffer systems the buffer on the strip may alter the *p*H on the remainder of the paper; but this can generally be avoided by adjustment of the buffer concentrations or by transferring a narrower strip.

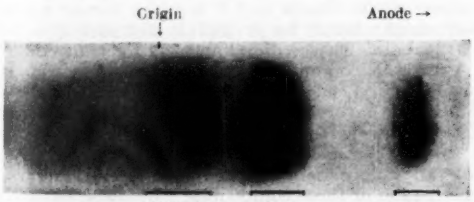


Fig. 1. Serum mucoprotein fractions *M*-1 and *M*-2 isolated by electrophoresis at *p*H 4·6 in a citric acid – sodium phosphate buffer. Paper stained by periodic acid – Schiff technique

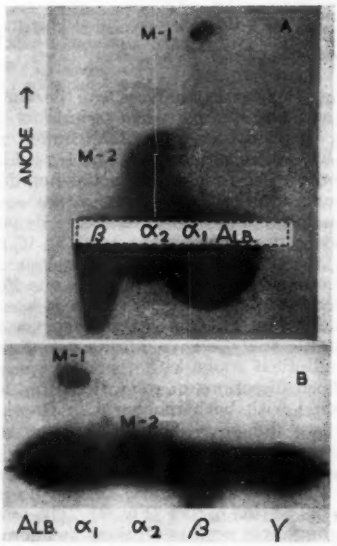


Fig. 2. Two-dimensional electrophoresis showing position of mucoprotein fractions in serum protein pattern obtained with veronal buffer, *p*H 8·6

(*A*) First separation transferred on paper strip, position of strip indicated by dotted line. Second buffer citric acid – sodium phosphate, *p*H 4·4

(*B*) Veronal buffer removed by 66 per cent acetone, second buffer citric acid – sodium phosphate, *p*H 4·6

Stained with naphthalene black. *M*-1 spots intensified for reproduction

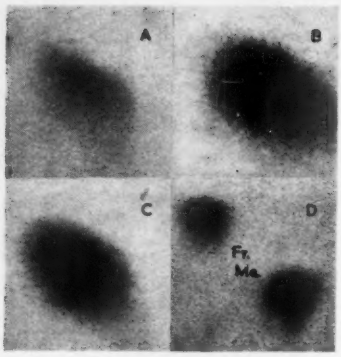


Fig. 3. Details of shapes of spots obtained by two-dimensional electrophoresis. Arrows indicate direction of migration in first and second analyses

	Substance	Buffer *p*H 1	2	
A	Serum, *M*-2	8·6	4·6	Stained with naphthalene black
B	Urine, *M*-1	8·6	4·4	" " " "
C	Serum albumin	8·6	8·6	" " " "
D Fr.	Fructose	8·6	8·6	Detected with *m*-phenylene-diamine. Borate buffer
D Ma.	Mannose	8·6	8·6	" " " "

Both electrophoretic analyses can be carried out on the same sheet of paper when serum mucoproteins are being studied, since veronal buffer may be removed by washing the paper in ice-cold 66 per cent acetone. The mucoproteins are not denatured by acetone, and the low temperature and rapid removal under vacuum avoid excessive denaturation of the other proteins present, which, if rendered insoluble, might retain some of the mucoprotein. The results of such an analysis are shown in Fig. 2 (*B*).

In the course of these experiments it was noticed that fractions appearing to be homogeneous after one electrophoretic analysis gave, after a two-dimensional analysis, elliptical spots with their long axes at an angle to both directions of migration (Fig. 3). This was observed with both mucoprotein fractions, run either at two different *p*H's or twice at the same *p*H, and with serum albumin run twice at *p*H 8·6. In a two-dimensional analysis using borate buffer at *p*H 8·6 [3], fructose and mannose showed no tendency to form spots of this nature (Fig. 3). The transferred strip technique was used in all these two-dimensional analyses, and both serum and urine were obtained from patients suffering from acute rheumatoid arthritis. The shapes of spots were not influenced by position on the paper, or by the order in which the buffers were employed. Kunkel and Tiselius[4] suggested that these diagonally disposed elliptical spots are the result of the presence of components with different mobilities within what appears to be a homogeneous fraction when subjected to a single electrophoretic analysis, and that the presence of such a spot-shape is a sensitive test for heterogeneity. No heterogeneity of these two mucoprotein fractions or of serum albumin was detected when patterns obtained by a single electrophoretic analysis were scanned, the curves obtained showing no sign of containing more than one component.

In the method reported here, where the same buffer has been used for each analysis, the fact that the axis of the elliptical spot is not at 45° to each direction of migration is due to the concentration of the spot on the base line before the second analysis. This reduces in one direction only the effect of diffusion on the shape of the spot. Kunkel and Tiselius were not able to demonstrate the heterogeneity of serum albumin by their method, and the ability of the method here described to do this may also be due to this reduction of diffusion by reconcentration, resulting in a more sharply defined spot.

Serum albumin[5] and mucoprotein *M*-2 [6] are each known to contain several components, but only one component is known to occur in mucoprotein *M*-1 of normal serum[7], and in normal serum a round spot is obtained on two-dimensional electrophoresis of the latter fraction. The intensity of this spot was too low for photographic reproduction. *M*-1 in serum of patients suffering from active rheumatoid arthritis, however, gives a diagonal ellipse and has been reported as containing two components, detected by boundary electrophoresis[8].

I thank Dr. Ernest Fletcher and the Board of Governors of the Royal Free Hospital for permission to publish this communication, and the Endowment Fund Sub-Committee for providing facilities. [Sept. 22

[1] Durrum, E. L., *J. Coll. Sci.*, **6**, 274 (1951).
[2] Markham, R. L., *Ann. Rheum. Dis.*, **14**, 212 (1955).
[3] Consden, R., and Stanier, W. M., *Nature*, **169**, 783 (1952).
[4] Kunkel, H. G., and Tiselius, A., *J. Gen. Physiol.*, **35**, 89 (1951).
[5] Saifer, A., and Corey, H., *Proc. Soc. Exp. Biol.*, **86**, 46 (1954).
[6] Schmid, K., *J. Amer. Chem. Soc.*, **75**, 2532 (1953).
[7] Schmid, K., *J. Amer. Chem. Soc.*, **75**, 60 (1953).
[8] Laurell, H., *Ark. Kemi*, **3**, 115 (1951).

CYCLIC POLYAMIDES FROM NYLON 6 and 6.6 POLYMERS

Constitution of the Cyclic Polyamides isolated from Nylon 6 Polymers

In a previous paper we reported the isolation from technical ε-caprolactam polymerizates of three individual crystalline substances (designated here as *A*, *B* and *C*) having identical elementary composition ($C_6H_{11}ON$) and containing no free NH_2 or COOH groups[1]. They obviously represent cyclic oligomers of ε-caprolactam.

Cryoscopic molecular-weight determinations in phenol at a concentration of about 5 per cent (by weight) led us to conclude that *A* and *B* are stereoisomeric cyclic dimers and *C* a cyclic trimer (molecular weight found for *A* and *B* 212 and 250; for *B* 342; calc., 226 for dimer and 339 for trimer).

A private communication received from Dr. L. Valentine in Leeds expressed doubt as to the reliability of the cryoscopic molecular-weight determinations (owing to the fact that no extrapolation to zero concentration was included). This led us to seek an independent method of determining the constitution of these compounds. Stepwise hydrolysis in aqueous (25 per cent by weight) hydrochloric acid at 110° (at a concentration of 0·5 repeating units, "Grundmole", per litre) was chosen. This procedure

was recently also suggested by Zahn *et al.*[2]; but no definite results were communicated.

Upon hydrolysis, a cyclic n-mer should produce the linear n-mer as the first product, which then is transformed into the linear $(n-1)$mer and so on, until complete conversion into ε-aminocaproic acid is reached.

A paper chromatographic technique[3] allowed us to separate, identify and estimate approximately quantitatively mixtures of the lower linear oligomers up to the tetramer.

Applying this technique, which will be published elsewhere in more detail, it was found that the intermediate product first appearing in the hydrolysis of the cyclic oligomers *A*, *B* and *C* were the linear dimer, trimer and tetramer respectively, providing conclusive evidence that *A*, *B* and *C* are indeed the cyclic dimer, trimer and tetramer.

The results of our hydrolysis experiments are in conformity with the extensive cryoscopic molecular-weight determinations of the same substances in solvents other than phenol (lactam of hexahydro-*p*-aminobenzoic acid and acetanilide) recently published by Rothe and Rothe[4]. These authors also confirmed anomalous results obtained in phenol as a solvent. It remains to be explained why the melting-point depressions of these substances in phenol are abnormally high.

The properties of these cyclic oligomers can now be summarized thus:

Substance	*A*	*B*	*C*
Melting point (corrected)	347–348°	247–248°	241–242°
Solubility in water, parts per 100 (17°)	0·1	0·93	0·04
Former designation (ref. 1)	α-dimer	β-dimer	trimer
Correct designation	dimer	trimer	tetramer
Molecular weight, cryoscopic method (ref. 4)	225	336	439
Molecular weight, calculated	226	339	452

The paper chromatographic identification of the linear oligomers was facilitated by samples of the synthetically prepared compounds obtained by courtesy of Dr. Van der Want, Central Laboratory TNO, Delft[5].

P. H. Hermans

Institute for Cellulose Research
of the AKU and Affil. Companies,
Utrecht.

[1] Hermans, P. H., *Rec. trav. chim.*, **72**, 798 (1953).
[2] Zahn, H., and Rexroth, E., Conf. Intern. de la Technica Textil (Barcelona, 1954).
[3] Hermans, P. H., Heikens, D., and van Velden, P. F., *J. Polymer Sci.*, **16**, 451 (1955).
[4] Rothe, J., and Rothe, M., *Ber.*, **88**, 284 (1955).
[5] van der Want, G. M., *et al.*, *Rec. trav. chim.*, **71**, 379 and 1221 (1952).

Intramolecular Hydrogen Bonds in certain Cyclic Polyamides

The intermediate products formed in the hydrolysis of the cyclic oligomers of ε-caprolactam and some linear oligomers of ε-aminocaproic acid (in a large excess of 25 weight per cent hydrochloric acid at 110°) have been identified and semi-quantitatively determined.

A paper chromatographic technique[1] has been used for this purpose. The results allowed determination of the approximate values of the pseudo first-order hydrolytic rate-constants of the amide groups in these substances. (The theoretical and experimental details of this work will be published elsewhere.)

The kinetic analysis of the hydrolysis of the linear oligomers was simplified by the assumption that the rate-constants of the amide groups in these linear polyamides are independent of chain-length and location in the chain, which seemed justified by a previous investigation[1].

Included in this investigation was also a cyclic diamide isolated from nylon 6.6 polymerizates obtained by courtesy of Dr. R. J. W. Reynolds (Manchester). This substance, which on hydrolysis yields the linear monoamide $NH_2(CH_2)_6NHCO(CH_2)_4COOH$ as an intermediate and hexamethylene diamine plus adipic acid as the final products, is isomeric with the cyclic dimer of caprolactam.

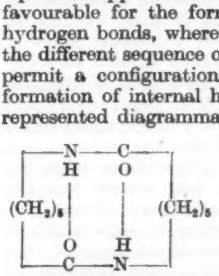
The approximate hydrolytic rate-constants in h^{-1} (for one amide group) of the substances investigated are given in Table 1 along with their solubilities in water at room temperature.

Table 1

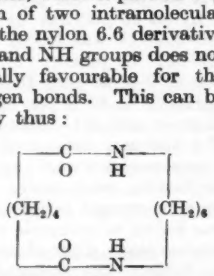
	Rate-constant (h^{-1})	Solubility (parts/100)
Caprolactam cyclic dimer	0·025	0·1
" " trimer	0·21	0·93
" " tetramer	0·15	0·04
Nylon 6.6 cyclic monomer	0·34	2·35
Linear ε-aminocaproic acid oligomers	0·34	—
ε-Caprolactam	> 2	320

These results disclose some interesting features. It is seen that the amide groups in caprolactam cyclic dimer are very resistant to hydrolysis as compared to those in the other cyclic lactam oligomers, and, in particular, as compared to the amide groups in the isomeric nylon 6.6 cyclic monomer, which react with practically the same rate as the amide groups in linear chains. Also the solubility in water of the nylon 6.6 derivative is more than twenty times larger than that of the lactam dimer. This peculiar difference requires explanation.

It would seem that the low reactivity of the cyclic dimer can be understood from the fact that in this compound the two CONH groups can readily assume a position opposite to each other, which is particularly favourable for the formation of two intramolecular hydrogen bonds, whereas in the nylon 6.6 derivative the different sequence of CO and NH groups does not permit a configuration equally favourable for the formation of internal hydrogen bonds. This can be represented diagrammatically thus:



Cyclic dimer



Nylon 6.6 monomer

Examination of Stuart models corroborates this view.

In the cyclic trimer, only two out of the three CONH groups could possibly form intramolecular hydrogen bonds with each other, and it seems to be not merely accidental that this oligomer is the one having by far the largest solubility in water. It also hydrolyses much easier than the dimer.

In the tetramer, pairwise engagement of all the CONH groups is again geometrically possible. Stuart models show that this is even possible in two different ways (Fig. 1).

Fig. 1

The fact that its rate-constant is nevertheless much larger than that of the dimer and but slightly smaller than that of the trimer is presumably related to the very much larger internal mobility of this 28-membered ring-system, which is also clearly demonstrated by the Stuart model. This mobility may favour the existence of a great many conformations in which the amide groups lie too far apart to allow intramolecular hydrogen-bond formation. The number of such conformations is undoubtedly much larger than in the dimer.

This paper and the preceding form part of a programme of fundamental research sponsored by AKU (Arnhem) and Netherland States Mines (Geleen).

P. H. Hermans

Institute for Cellulose Research
of the AKU and Affil. Companies,
Utrecht.

[1] Hermans, P. H., Heikens, D., and van Velden, P. F., *J. Polymer Sci.*, **16**, 451 (1955).

Constitution of the Cyclic Polyamides isolated from Nylon 66 Polymer

When nylon 66 polymer (polyhexamethylene adipamide) is heated in a glass vessel under an inert atmosphere above its melting point, a white crystalline sublimate condenses on the cooler parts of the vessel. A similar phenomenon occurs in the melt-spinning of nylon, when a sublimate condenses on the cooler parts of the spinning equipment just below the spinneret. It was obviously of interest to know whether this material was a by-product of the polymerization process or of thermal decomposition of the polymer.

A sample of the crystalline material sublimed out of nylon 66 polymer by heating it under vacuum at 295–300° C. was found to have a melting point of 249–251° C. (uncorr.): its analysis showed 63·6 per cent C, 9·8 per cent H and 12·4 per cent N (calc. for $C_{12}H_{22}N_2O_2$, 63·8 per cent C, 9·75 per cent H and 12·4 per cent N). This material had refractive index of 1·554 and density of 1·166 gm./c.c.

In some later work, nylon 66 polymer was extracted by boiling with water for a long period and the aqueous extract evaporated to dryness. The residue was found to comprise two materials—one soluble in ethyl acetate, from which it crystallized, and the other insoluble; the insoluble portion was purified by recrystallization from methyl 'Cellosolve'.

The material soluble in ethyl acetate was found to be identical with the material which had been sublimed from 66 nylon polymer. Its melting point was 248° C. and by analysis was found 63·3 per cent C, 9·6 per cent H and 12·2 per cent N. Molecular weight determination gave 210 (by cryoscopic method in phenol), 218 (by ebullioscopic method in methanol) and 225·2 by X-ray diffraction assuming two molecules per unit cell. The dimensions of the triclinic unit cell were $a = 9{\cdot}58$ A.; $b = 8{\cdot}71$ A. and $c = 8{\cdot}47$ A., with angles $\alpha = 110°\ 58'$; $\beta = 104°\ 35'$ and $\gamma = 86°\ 17'$. The specific gravity of the crystals, measured by flotation, was 1·171. The calculated molecular weight for $C_{12}H_{22}O_2N_2$ is 226.

The material insoluble in ethyl acetate crystallized from methyl 'Cellosolve' in fragile white crystals with melting point 237° C. On analysis its composition was found to be 63·2 per cent C, 9·6 per cent H and 12·2 per cent N. Molecular weight determination (by ebullioscopic method in methanol) gave 445.

The crystals were not good enough for unit cell measurements to be made, but the powder diffraction pattern was different from that of the soluble fraction in ethyl acetate.

It seemed probable that these two compounds were cyclic hexamethylene adipamide monomer and dimer respectively.

It is possible to obtain a mixture of low-molecular weight materials comprising mainly these two compounds by dissolving 66 polymer in formic acid and adding the solution slowly to a large volume of methanol, so that the polymer is precipitated in a granular and easily filterable form. The 'methanol-soluble' material can be recovered by filtering off the polymer and evaporating the filtrate to dryness. Using this procedure as a method of analysis, it has been shown that the low-molecular weight compounds are formed from the linear polymer, and that the amount formed is dependent upon the temperature to which the polymer is heated. A single experiment indicated that the reaction is reversible. The amount of 'methanol-soluble' material found varied from 1·9 per cent after heating at 275° C. to 4·3 per cent at 295–300° C. and 5·9 per cent at 310° C.

C. J. Brown
A. Hill
P. V. Youle

Research Laboratories,
Imperial Chemical Industries, Limited,
Dyestuffs Division,
Hexagon House, Blackley,
Manchester, 9.

Synthesis of 1 : 8-Diazacyclo-tetradecane

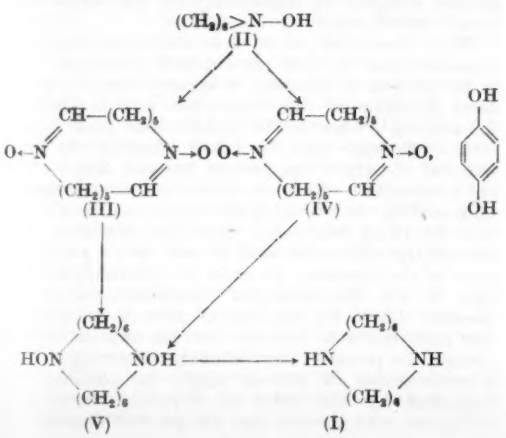
The 14-membered-cyclic diamine (I) has been synthesized in these laboratories by three entirely independent routes. In two of these the large-ring diamides discussed in Dr. P. H. Hermans' communications were the starting materials. Both the nylon 6 : 6-cyclic monomer, kindly supplied by Dr. R. J. W. Reynolds, and the cyclic dimer from caprolactam, kindly supplied by Dr. Hermans, were reduced by lithium aluminium hydride in boiling tetrahydrofuran without difficulty. The identity of the reduction product from these two sources thus provides chemical proof of the cyclic systems, no other structures leading to a common product. The diamine is strongly basic, melting point 72°, boiling point 145°/12 mm., dipicrate melting point 248° C., dihydrochloride melting point 315–9° C.

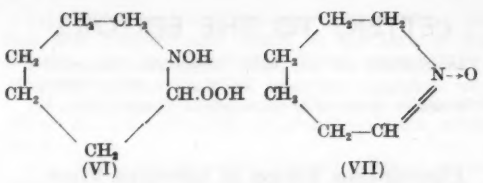
The third route is less to be expected, and uses as starting material N-hydroxyhexamethyleneimine (II), boiling point 94–5°/13 mm., melting point 7° C., which has been prepared by two methods[1], and the structure assigned to it has been confirmed by analysis of the base, its hydrochloride, acid oxalate and picrate, and by its reduction to hexamethyleneimine. It behaves normally as a hydroxylamine in

every respect save only the remarkable sensitivity of the free base to atmospheric oxygen. It is characteristic of N-dialkylhydroxylamines to autoxidize very rapidly in aqueous alkali[2], and very slow oxidation often takes place on keeping the free base in air. N-Hydroxyhexamethyleneimine is so sensitive to oxygen that all operations must be carried out in an atmosphere of nitrogen. Exposure to oxygen for a few minutes leads to cloudiness and for longer periods to the precipitation of a flocculent, amorphous, and no doubt polymeric, solid, which is insoluble in practically all solvents. Eventually (after some weeks) a film of the hydroxylamine exposed to air will set to a brittle solid.

The phenomenon shows particularly clearly in ether solution, which soon becomes opaque and strongly peroxidic to starch iodide paper; and after a few hours, especially when oxygen is passed through the solution, deposits a film on the walls. It was observed that the deposit, though largely amorphous, contained traces of crystalline material, and this has been isolated in very low yield and found to be very labile, losing its solubility in organic solvents when heated to temperatures approaching 100° C. It was then found that much more crystalline material was formed when quinol in roughly half-molecular amounts was present during the oxidation, and that the product was much less heat-labile, though becoming insoluble in organic solvents at temperatures above 100° C. Analysis of this latter compound suggested an empirical formula $C_{16}H_{28}N_2O_3$, that is, a combination of quinol and a dimerized oxidation product of N-hydroxyhexamethyleneimine. To the two crystalline products have been assigned structures (III) and (IV). On hydrogenation of (IV) by Adams catalyst in methanol, four atoms of hydrogen are absorbed, and the products are free quinol and a new compound (V) with the properties of a hydroxylamine. Compound (III) can be reduced in the same way, and the X-ray powder patterns and infra-red absorption curves of the products are identical. Dr. C. J. Brown of these laboratories has examined crystals of (V) by X-ray diffraction and has deduced that a large ring (12-, 14- or 16-membered) is consistent with all the intensity results; but as yet the final electron-density map showing the position of the atoms has not been obtained.

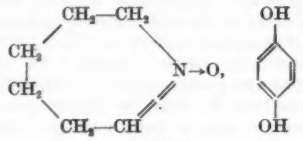
Compound (V) has now been hydrogenated further with Raney nickel in glacial acetic acid to the cyclic diamine (I), this constituting the third synthesis.



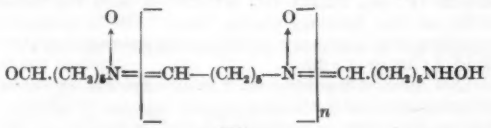


The structure assigned to (IV) leaves open the question of whether the quinol is bound to the nitrone by covalent or ionic bonds or as a molecular complex or clathrate system.

It is now possible to see how N-hydroxyhexamethyleneimine polymerizes during autoxidation, though no really convincing explanation of why it does so has yet been suggested. The first product is probably the hydroperoxide (VI), and indeed very labile, strongly peroxidic, solids have been detected, but isolation has not been possible. Hydrogen peroxide is eliminated from (VI) leaving the cyclic nitrone (VII), which can be shown to be unstable and to polymerize, for it can be made by a different route: N-hydroxyhexamethyleneimine reacts rapidly with quinone in ether with hydrogen transfer and formation of the complex (VIII), a crystalline solid, which, after a few hours, changes to a resinous polymeric material, insoluble in solvents, and quinol.



Again the question of the precise structure of the complex is reserved for further discussion. The polymer formed by autoxidation is thought to be of rather low molecular weight, and is represented:



In agreement with this, reduction by Raney nickel in glacial acetic acid gives polyamines, showing positive spot tests for both primary and secondary amines. The water formed during the oxidation, via hydrogen peroxide, is probably an effective chain stopper. The strong reducing properties, to triphenyltetrazolium chloride[1], suggest a high proportion of hydroxylamine groups.

Full details of this work will be submitted to the *Journal of the Chemical Society* for publication.

I acknowledge gratefully the help of Drs. E. J. Alford and J. A. Hall, and the crystallographic examination by Dr. C. J. Brown.

M. A. Thorold Rogers
Research Laboratories,
Imperial Chemical Industries, Limited,
Dyestuffs Division,
Hexagon House,
Blackley,
Manchester, 9.

[1] Rogers, M. A. T., *J. Chem. Soc.*, 769 (1955).
[2] Rogers, M. A. T., *J. Chem. Soc.* (in the press).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Filamentous Forms of Influenza Virus

THERE is good evidence that the filamentous forms characteristic of many recently isolated strains of influenza A are infective units[1]; but their significance in relation to the process of influenza virus replication is by no means clear. It has been suggested that filaments represent the initial form in which the infective phase of the virus is produced, spheres being formed secondarily[2]. Others have suggested that the filament is a by-product, as it were, of the process by which new infective particles are produced at the free surface of the allantoic cell[3].

Although it has been known since 1949[4] that the filaments are clearly visible by dark-ground illumination at a magnification of 500 or even less, very little use has been made of this method of observation. It has, however, a number of advantages over the conventional use of the electron microscope for such work. A simple, and for most purposes sufficiently accurate, method of comparing concentrations of filaments is as follows. A standard volume, 20 c.mm., is placed on a clean slide and covered carefully with a coverglass of standard size ($\frac{7}{8}$-in. circle). The preparation is put into a moist chamber for 15 min. or longer to allow the great majority of the filaments to attach themselves to one or other glass surface. Using a standard area of field with an 'Ehrlich' eyepiece and a 47× objective, the number of filaments on the two glass surfaces plus the few seen in moving from one focal level to the other can be readily counted. To a reasonable approximation the number of filaments per field area X is equivalent to $X \times 10^7$ filaments per c.c., and with the highly filamentous strains Oc. Is., *PERS* and *RYAN*, X is of the same order as the hæmagglutinin titre. For convenient counting it is necessary to dilute the average infected fluid 1 : 10 or 1 : 20.

This method has been used in an exploratory series of investigations for finding agents capable of destroying the filaments as estimated by the reduction in the numbers of visible forms. The interesting result has emerged that most agents capable of hæmolysing red cells will destroy virus filaments and show a threshold at about the same level of concentration. Hypotonic salt solutions are destructive at concentrations of 0·3 per cent sodium chloride or lower. At or near threshold concentrations, distorted forms with angulation and a beaded appearance may be seen; at lower concentrations forms recognizable as filaments become extremely rare. Disintegration is more rapid and complete at *p*H 6 than at *p*H 8.

As representative hæmolytic agents saponin, cetyltrimethylammonium bromide and sodium lauryl sulphate were used. They were completely destructive at concentrations of 0·01 per cent, but had virtually no effect at a concentration of 0·001 per cent. The end point of hæmolysis of 1 per cent fowl cells also lay between these concentrations. Saponin was less active in the sense that few filaments were completely destroyed. Obvious evidence of damage was produced to a concentration of 0·003 per cent in the form of distortion, beading and, particularly around 0·01 per cent, very firm adsorption to glass surfaces. The damage was confirmed in electronmicrographs made for me by Dr. Heather Donald.

Shaking with ether or chloroform destroys the filaments. Using the normal procedure of shaking infective fluid with 20 per cent of freshly redistilled ether and leaving overnight in the refrigerator, virtually all filaments were destroyed. The hæmagglutinin titre showed a moderate fall when tested with fowl cells; but a rise with human or guinea pig cells. Untreated, the strain Oc. Is. gave fowl-to-human hæmagglutinin titres of 600/700, after treatment with ether 300/3,200. Of non-filamentous strains similarly treated, only *PR*8 showed a change of this type from 500/700 to 130/600. Infectivity titrations showed no reduction beyond 0·5 $\log_{10}$ when treatment was with redistilled ether on allantoic fluid buffered with phosphate at *p*H 7·0. The same lack of effect on infectivity was seen when filaments were broken down with water lightly buffered at *p*H 7·0 or 8·0.

The results suggest that the filaments have qualities resembling those of the host cell surface, and that their formation is a result of an interaction of virus components with the surface of the cell in which virus has multiplied. Failure to influence infectivity by filament destruction may mean that their infectivity is limited to the spherical units that often appear to be incorporated in the filaments.

F. M. BURNET

Walter and Eliza Hall Institute,
Melbourne. Oct. 26.

[1] Donald, H. B., and Isaacs, A., *J. Gen. Microbiol.*, **11**, 325 (1954).
[2] Flewett, T. H., and Challice, C. E., *J. Gen. Microbiol.*, **5**, 279 (1951).
[3] Hotz, G., and Schafer, W., *Z. Naturforsch.*, **10**, 1 (1955).
[4] Chu, C. M., Dawson, I. M., and Elford, W. J., *Lancet*, i, 602 (1949).

Reactivation of Partially Degraded Tobacco Mosaic Virus

RECENT infectivity studies with partially degraded tobacco mosaic virus have led to the inference that the virus particles can remain active after some of the protein has been experimentally removed so as to expose portions of the ribonucleic acid core[1,2]. In one of these studies[2] it was found that, upon heating the virus briefly with a detergent, the infectivity was reduced from that in the original sample by a factor of 4–10; most of the activity then remaining was found to reside in partially degraded virus particles, as judged by the fact that their infectivity could be greatly reduced by digestion with crystalline pancreatic ribonuclease.

While there is as yet no clear understanding of the separate roles of virus protein and ribonucleic acid in the process of infection, it appears that the structural integrity of the ribonucleic acid is essential for activity[2], whereas the protein coat need not be intact. It may then be asked whether the mere removal of part of the protein has any direct effect on infectivity. Such an effect is not necessarily indicated by the partial inactivation occurring in the heat-detergent treatment, since the treatment may disrupt the ribonucleic acid as well as the protein in some of the particles. In order to determine whether part of the heat-detergent inactivation might be directly due to the removal of protein, an attempt has been made to reverse this inactivation by replacing the protein removed in the treatment. That a replacement of protein might be possible was suggested by the work of Fraenkel-Conrat and Williams[3], who showed that the purified protein and

Table 1. Effect of Treatment upon Infectivity of Tobacco Mosaic Virus
(Ratio of infectivity of treated to untreated material)

Treatment	Exp. 1	Exp. 2	Exp. 3
Heat-detergent treatment	0·06	0·04	0·044 ± 0·004
Heat-detergent treatment followed by reactivation treatment	0·3	0·5	0·29 ± 0·05

ribonucleic acid components of tobacco mosaic virus can be combined *in vitro* to form active virus particles.

The heat-detergent treatment was like that described previously[2], except that the heating period was changed from 6 sec. to 10 sec. In material treated for the longer period, it was found that about 15 per cent of the total ribonucleic acid was so exposed as to be digestible with ribonuclease (in contrast with a possible exposure of less than 5 per cent following the shorter treatment). About 5 per cent of the original infectivity remained, and most of this could be destroyed by ribonuclease digestion.

In the reactivation treatment, a solution containing about 0·01 mgm./ml. heat-detergent treated tobacco mosaic virus and 1 mgm./ml. purified protein of tobacco mosaic virus (prepared by Dr. H. Fraenkel-Conrat[3]) was made 0·01 *M* in acetate by the addition of 3 *M* acetate at *p*H 6. The mixture was then allowed to stand at room temperature for a period of 4–24 hr. before final dilution and assay[2].

Table 1 lists the results of three separate reactivation experiments performed with the same initial preparations of the purified virus and virus protein. The uncertainties of measurement (corresponding roughly to 95 per cent confidence limits) are indicated only for the third experiment, which differed from the others in that the dilutions of the inocula compared had been so adjusted that they produced approximately the same numbers of local lesions on the test plants. In the assays where lesion numbers were not well matched, it was necessary to assume proportionality between lesion number and infectivity over wide ranges in order to estimate the infectivity ratios. Since the accuracy of this assumption is questionable, it would be misleading to give estimates of uncertainty based only on the variations in the results of those assays. A number of additional reactivation experiments were done with different starting preparations of the virus and virus protein. While the results were not always in close quantitative agreement with those given here, all were qualitatively consistent in indicating a rise in the infectivity of heat-detergent treated tobacco mosaic virus upon standing in the presence of the purified protein.

The explanation offered for the above results is that the reactivation treatment does replace some or all of the protein removed from the particles in the heat-detergent treatment. A direct demonstration of this reaction by chemical methods was considered impractical because of the relatively small amount of protein which would be involved; however, a number of biological tests have been made in order to check the hypothesis. These tests are described below.

(1) The purified protein alone was found to be non-infectious, and it could not be 'reactivated' by treatment with acetate alone. (Similar results have been previously reported[2].)

(2) The heat-detergent treated virus did not increase in infectivity upon standing in water or in acetate solution alone.

(3) When the heat-detergent treated virus, protein and acetate were mixed at the time of final dilution (that is, immediately before assay) little or no reactivation took place.

(4) The reactivation treatment had little or no effect on the infectivity of intact tobacco mosaic virus.

(5) The heat-detergent treated tobacco mosaic virus could not be reactivated after exposure to ribonuclease. Also, when ribonuclease, protein of tobacco mosaic virus, and acetate were added simultaneously to heat-detergent treated virus, and the mixture allowed to stand, the infectivity was then reduced from that in the initial heat-detergent treated sample. When the addition of the ribonuclease for such a mixture was postponed until 24 hr. after the addition of the protein and acetate, the reactivated sample then showed little or no reduction of infectivity upon standing with the enzyme.

The last result indicates that after the reactivation treatment the ribonucleic acid is no longer exposed to ribonuclease digestion; thus it appears that protein has indeed been added to the particles. However, even though the ribonucleic acid is apparently 'covered', less than half the original infectivity is restored. The experimental results described here do not indicate whether the final deficit from the starting infectivity is due to chemical changes in the ribonucleic acid or to defects in the protein coat (other than 'gaps' large enough to permit attack by ribonuclease). The results do indicate that about one-fourth (and perhaps more) of the inactivation of tobacco mosaic virus in the heat-detergent treatment may be accounted for by the removal of part of its protein.

I am grateful for the advice and assistance of Drs. Robley C. Williams, Heinz Fraenkel-Conrat and C. Arthur Knight.

Roger G. Hart*

Virus Laboratory,
University of California,
Berkeley, California.
Oct. 21.

* U.S. Public Health Service Research Fellow of the National Cancer Institute.

[1] Schramm, G., Schumacher, G., and Zillig, W., *Nature*, **175**, 495 (1955).
[2] Hart, R. G., *Virology*, [1, 402 (1955)].
[3] Fraenkel-Conrat, H., and Williams, R. C., *Proc. U.S., Nat. Acad. Sci.* [41, 690 (1955)].

Multiplicity Reactivation of Bacteriophage

Luria and Dulbecco[1] formulated the most simple theory that could account for multiplicity reactivation. They supposed that each bacteriophage particle contains a certain fixed number of genetic units; if one or more of these units is damaged by irradiation, the particle will not multiply unless it shares a bacterium with other particles which can supply undamaged versions of the units needed to make a complete set. Therefore the probability that a multiple-infected bacterium (multicomplex) contains a complete set of undamaged units should be simply a function of the number of units in a particle, the proportion of units which have been damaged by irradiation, the number of particles per bacterium (multiplicity), and the distribution of particles among bacteria. Early experiments showed that, within certain limits, this probability (termed 'the survival of multicomplexes') behaved in the expected way

when multiplicity and degree of irradiation were varied.

Later, Dulbecco[2] subjected the theory to a stricter test in the range where prolonged irradiation of the particles makes subsequent multiplicity reactivation a very rare event. According to the proposed theory, as the time of irradiation is increased the slope of the curve of survival of multicomplexes against time of irradiation should approach the slope of the curve of survival of single particles. In fact, the decline in survival of multicomplexes was shown to occur much less rapidly. Since no simple process of unit substitution could be more efficient than the proposed one, the recombination theory of multiplicity reactivation was therefore regarded as disproved.

Variation in bacterial size would produce exactly this effect. In an extreme case, the decline in survival of multicomplexes with increasing irradiation would merely represent decline in the number of cells large enough to have collected enough particles to ensure the presence of one complete set of undamaged units. We have therefore recalculated expectations for Dulbecco's experiments, incorporating the frequency distribution of cell-sizes given by Dulbecco in an appendix to the earlier paper. We have assumed that there is a Poisson distribution of bacteriophage particles over the bacterial surfaces, that the bacterial lengths given by Dulbecco can be equated with surface areas, and that there is no loss through lysis-from-without. We have also had to assume that a frequency distribution of cell-sizes, based upon measurement of 764 cells, is adequate for predicting events which have a frequency of 10^{-4} to 10^{-7}.

As shown in Fig. 1, the agreement between observation and recalculated expectation is surprisingly good, considering the uncertainties of the calculation. The observed survival of multicomplexes is now seen to be close to, or rather lower than, expected. Therefore, it seems no longer necessary to seek an alternative to the recombination theory of multiplicity reactivation.

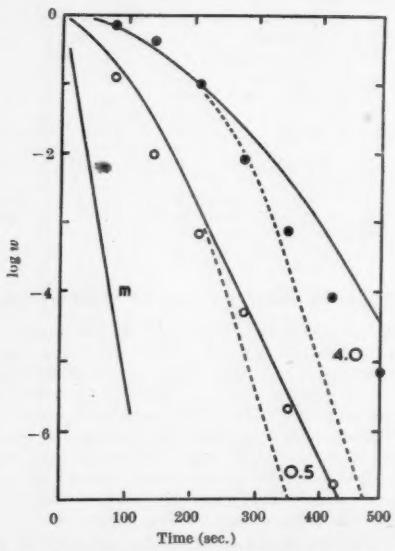


Fig. 1. Effect of increasing irradiation on the survival of multicomplexes. The proportion of surviving multicomplexes (w) is plotted against the time of irradiation for the two multiplicities, 0·5 and 4·0 bacteriophage particles per bacterium. Broken lines represent the expected survival as calculated by Dulbecco, assuming a Poisson distribution of particles among bacteria; solid lines are for the recalculated distribution, assuming a Poisson distribution of particles over the bacterial surfaces. Each particle was taken to contain 25 units. The points and the curve for survival of single particles (m) are from Dulbecco's paper

H. J. F. Cairns

Department of Microbiology,

G. S. Watson

Department of Statistics,
Australian National University,
Canberra.

Aug. 12.

[1] Luria, S. E., and Dulbecco, R., *Genetics*, **34**, 93 (1949).
[2] Dulbecco R., *J. Bact.*, **63**, 199 (1952).

Composition of a Hypertensin Peptide

The isolation of a homogeneous pressor peptide (hypertensin or angiotonin) made by the action of rabbit renin on ox serum was previously reported by me[1]. Further quantitative study on the composition of this pressor peptide has shown the empirical structure to be:

One residue: leucine, phenyl alanine, tyrosine, proline, aspartic acid and arginine.

Two residues: valine and histidine.

This gives a minimum molecular weight of 1,445. The distinction between aspartic acid and asparagine has not yet been made.

Only one N-terminal amino-acid, aspartic, was found, using the dinitrofluorobenzene technique[2], and this was supporting evidence of homogeneity.

The hypertensin peptide recently described by Skeggs, Marsh, Kahn and Shumway[3] differed only by the presence of *iso*leucine in place of one of the two valine residues. This would presumably represent a species difference, since these workers used pig renin and horse serum substrate. The N-terminal amino-acid was not stated, and no further comparison is possible.

W. S. Peart

National Institute for Medical Research,
Mill Hill,
London, N.W.7.

Oct. 24.

[1] Peart, W. S., *Biochem. J.*, **60**, vi (1955).
[2] Sanger, F., and Thompson, E. D. P., *Biochem. J.*, **53**, 353 (1953).
[3] Skeggs, L. T., Marsh, W. H., Kahn, J. R., and Shumway, N. P., *J. Exp. Med.*, **100**, 363 (1954); **102**, 435 (1955).

Effect of Antibody on the Respiratory Rate of *Trypanosoma vivax*

The West African N'Dama breed of cattle shows a remarkable tolerance to trypanosomiasis, as was demonstrated by Chandler[1]. In order to investigate the nature of this tolerance, it was necessary to develop a technique which would give a quantitative estimation of antibody titre. Methods employed in the study of bacteriological immunity are not generally applicable to the study of the immune response as it occurs in African trypanosomiases. Tests such as the mouse protection test employed by Fiennes[2] in studying *T. congolense* infections do not readily give a quantitative estimate of antibody titre and are operative only when the trypanosomes survive in the host as a patent or latent infection.

It was noted that the oxygen consumption of two strains of *T. vivax*, one cyclically transmitted and maintained in sheep and the other adapted to rats and passaged by syringe, showed a marked decrease

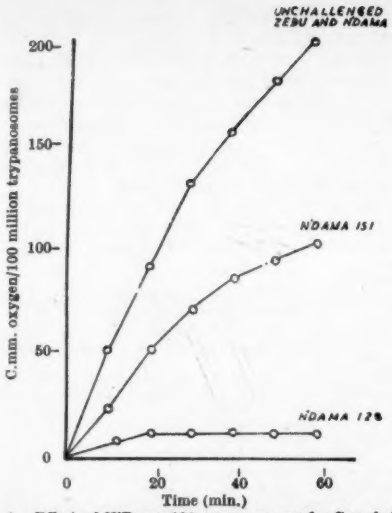


Fig. 1. Effect of N'Dama 128 serum one week after challenge, and N'Dama 151 serum 42 months after challenge, on the oxygen consumption of the rat strain of *T. vivax*

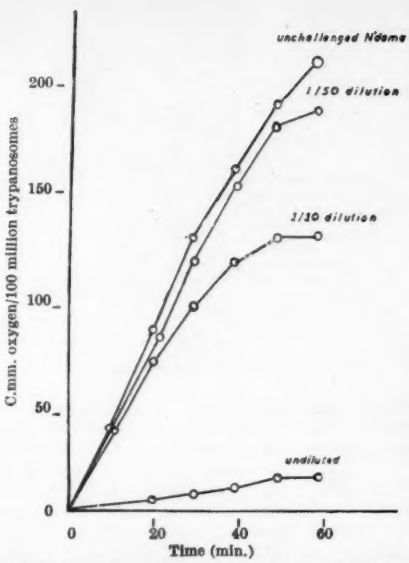


Fig. 2. Oxygen consumption of the rat strain of *T. vivax* suspended in unchallenged N'Dama sera and in various dilutions of N'Dama 128 serum

when suspended in sera of N'Dama cattle previously challenged with this species of trypanosome. It was afterwards found that the rat strain, adapted to this host by a method described by Desowitz and Watson[3], was considerably more sensitive to the action of the sera than the sheep strain. The reduction in oxygen consumption appears to be caused by a species-specific antibody in the N'Dama serum as indicated by accompanying trypanolysis. Furthermore, the degree of inhibition of oxygen consumption seems to be related to the titre of antibody present, since the degree decreases as the period after challenge increases (see Fig. 1). No inhibitory effect occurs with sera from unchallenged Zebu or N'Dama cattle, indicating the absence of any 'natural' antibody possessed by the N'Dama breed.

N'Dama 128 was challenged with the sheep strain of *T. vivax*. A few parasites appeared in the blood three days following challenge, after which no trypanosomes were seen. One week after challenge serum was obtained and was found to effect an almost total suppression of oxygen consumption of the rat strain. Lysis of all trypanosomes was noted after an experimental run of 1 hr. The effect on the respiration-rate of the rat strain of *T. vivax* of various dilutions of N'Dama 128 serum with unchallenged N'Dama serum is shown in Fig. 2.

In December 1952, N'Dama 151 was challenged with a strain of *T. vivax* that had been maintained in Zebu cattle; a low-grade intermittent parasitæmia persisted until August 1953, after which time no parasites were detected in the blood. In June 1955, serum from this animal was found to suppress partially the oxygen consumption of the rat strain of *T. vivax*, indicating that antibody in N'Dama serum may persist for some two years.

All trials were carried out in conventional Warburg respirometers for 1 hr. at 36·5° C.; 2 ml. sera were placed in 20-ml. flasks and trypanosomes added to give a suspension of 30–60 million trypanosomes per cm.³. The method is believed to be rapid and simple in giving a quantitative estimation of antibody titre in the immune response to trypanosomiasis. Full details of the comparative immune response of Zebu and N'Dama breeds will be published elsewhere.

R. S. Desowitz

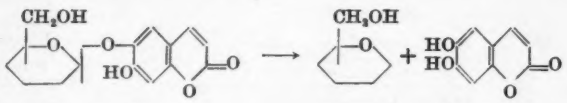
Veterinary Section,
West African Institute for
Trypanosomiasis Research,
P.O. Vom, Northern Nigeria.

Aug. 16.

[1] Chandler, R. L., *Ann. Trop. Med. Parasit.*, **46**, 127 (1952).
[2] Fiennes, R. N. T.-W., *Ann. Trop. Med. Parasit.*, **44**, 42 (1950).
[3] Desowitz, R. S., and Watson, H. J. C., *Ann. Trop. Med. Parasit.*, **46**, 92 (1952); **47**, 247 (1953).

Splitting of Aesculin by Yeasts

The ability to split aesculin into glucose and the phenolic aglycone, aesculetin, has been used in classifying yeasts[1–3] and other micro-organisms, such as the streptococci[4]. Lodder and Kreger-van Rij[5] also used arbutin, another β-glucoside, for this purpose, parallel tests with the two glucosides having given the same results[6].



[Na_2CO_3 solution λ max. 376 mμ λ max. 398 mμ]

We find that all yeasts we have tested are capable of splitting aesculin under appropriate conditions of nutrition. Our survey included 115 different strains (Table 1), mainly obtained from the chief national culture collections. Ninety-one of these strains are listed as species which are said not to split arbutin[5] and therefore, *a priori*, were not expected to hydrolyse aesculin[3,6].

Table 1. Types of Yeast Used

Classification (refs. 3, 5)	Number of strains
Saccharomycetaceae	
Saccharomyceteae	
Saccharomyces	87*
Pichia	5
Hansenula	5
Debaryomyces	1
Cryptococcaceae	
Cryptococcoideae	
Cryptococcus	1
Torulopsis	1
Candida	5
Kloeckera	6
Rhodotoruloideae	
Rhodotorula	3
Sporobolomycetaceae	
Sporobolomyces	1

* Includes 11 strains of *Saccharomyces cerevisiae*

The techniques we used differ from those of previous workers[1,2,5], both for growing the yeast cells and for assessing the splitting activity. The yeasts were grown on malt–yeast–glucose–peptone agar[3] in Roux bottles at 25° C. for three days. The growth was washed off the agar surface with 10 ml. of a synthetic medium (*A*2), containing trace elements, vitamins, salts, ammonium sulphate, but no source of carbon[3]. 2 ml. of this suspension was pipetted into a *T*-tube[3] and another 2 ml. of the same medium, containing 0·05 per cent aesculin sterilized by Seitz-filtration, added.

The tubes were shaken[3] for 20 hr., the yeast suspension centrifuged, and the supernatant liquid extracted with ethyl acetate (5 ml.). 3 ml. of the upper layer was shaken with 1·5 *M* sodium carbonate solution (5 ml.) in a separating funnel. The yellow colour in the aqueous phase was due to aesculetin, as shown by its characteristic ultra-violet absorption spectrum ($\lambda_{max.}$ 398 mμ), and in every case contrasted markedly with that of the control. The colour change was measured with a spectrophotometer.

Results were quite different when the yeasts were grown on the *A*2 synthetic medium[3] to which 1 per cent glucose and 2 per cent agar had been added. After growth on this medium, which is less rich than the malt–yeast–glucose–peptone agar, only about half the strains split aesculin measurably. For example, the following seven strains split about 50 per cent or more of the aesculin in 20 hr. when grown on the complex medium, but less than 5 per cent if cultured on the synthetic medium: in each case the cell suspension introduced from the synthetic medium into the aesculin medium was of the same order of size as that from the complex malt–yeast–glucose–peptone agar medium:

Pichia membranaefaciens (CBS 10)
Saccharomyces acidifaciens (CBS 26)
Saccharomyces bisporus (NCYC 171)
Saccharomyces carlsbergensis (NCYC 324)
Saccharomyces cerevisiae (NCYC 176)
Saccharomyces fermentati (CBS 13)
Saccharomyces rouxii (CBS 24)

(NCYC: National Collection of Yeast Cultures.
CBS: Centraalbureau voor Schimmelcultures; the CBS number in each case refers to the Zygosaccharomyces strain in the 1950 catalogue.)

We conclude that the ability to split aesculin is far more widespread among yeasts than has been suspected hitherto. This fact may have been unnoticed so far because (*a*) the yeasts have been grown on nutritionally poor media; (*b*) much smaller inocula have been used; and (*c*) the methods for detecting aesculetin have been relatively insensitive. There has been no mention previously of any one α- or β-glycoside, including disaccharides, which is split by so many kinds of yeast.

We intend to publish a full account of this work later. It was carried out as part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research.

J. A. Barnett
T. Swain

Low Temperature Station for
Research in Biochemistry and Biophysics,
University of Cambridge and
Department of Scientific and Industrial Research.
Sept. 3.

[1] Stelling-Dekker, N. M., "Die Sporogenen Hefen" (De Koninklijke Akademie van Wetenschappen, Amsterdam, 1931).
[2] Wiles, A. E., *J. Inst. Brew.*, **59**, 265 (1953).
[3] Lodder, J., and Kreger-van Rij, N. J. W., *Laboratory Practice*, 3, 483 (1954).
[4] Breed, R. S., Murray, E. G. D., and Hitchens, A. P., "Bergey's Manual of Determinative Bacteriology" (Baillière, Tindall and Cox, London, 6th edit., 1948).
[5] Lodder, J., and Kreger-van Rij, N. J. W., "The Yeasts" (North Holland, Amsterdam, 1952).
[6] Lodder, J. (personal communication).
[7] Ingram, M., "An Introduction to the Biology of Yeasts" (Pitman, London, 1955).
[8] Wickerham, L. J., *Tech. Bull. U.S. Dep. Agric.*, 1029 (1951).
[9] Barnett, J. A., and Ingram, M., *J. App. Bact.*, **18**, 131 (1955).

A Dielectric Study of the Low-Conductance Surface Membrane in *E. coli*

Dielectric studies have shown that the low electric conductivity of many biological cells originates in an extremely thin layer—apparently of the order of 30 A. thick—located somewhere in the cell envelope, presumably in the cytoplasmic surface structure[1]. This insulating structure is called here the 'low-conductance surface membrane'.

Although it has been repeatedly shown[2] that the conductivity of bacteria is well below that of the suspending medium, it is not yet known whether the conductivity lies in the range of very low values found in other types of cells. Neither is it known whether the control of the conductivity lies in the cell envelope. In order to throw light on these questions, we have examined suspensions of *E. coli* (*B*), taken from a 20-hr. culture in aerated nutrient broth ('Difco') at 37° C.

To obtain significant information on the conductivity of the bacterial cell, it is necessary to work with very dense suspensions. This was done by centrifuging the bacteria into a plastic conductivity cell mounted on a fast centrifuge. Similar observations at lower speeds were reported many years ago by Shearer[3a]. To enable us to take into account[1a] the conductance of the residual medium, its volume was determined by suspending the bacteria in dilute hæmoglobin and measuring the amount of the protein left between the packed cells. The method is still under development; but it is clear that the conductivity of the bacterial cell is quite low, the upper limit set by the present observations (taken at 50 kc./s.) being 10 per cent of that of the suspending sodium chloride or sodium plus calcium chloride medium. (In contrast to Shearer[3a], we found *E. coli* to be quite stable in pure sodium chloride (without calcium), both in terms of conductivity and viability.)

To determine the cause of the low conductivity of the bacteria, their conductivity and dielectric constant were measured over a frequency-range of 50 c./s., to 150×10^6 c./s., using three different bridges and conductivity cells[1a,1b,3a,3b]. The effect of

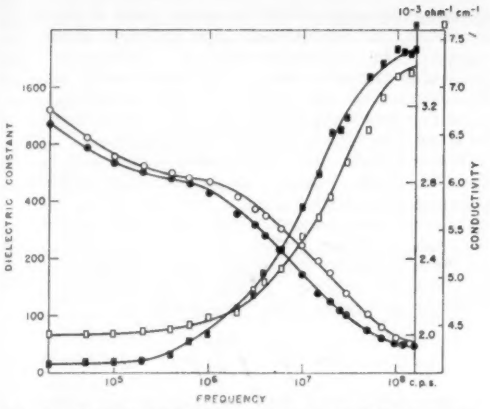


Fig. 1. Dielectric constant (circles) and conductivity (squares) of *E. coli B* in 0·25 per cent sodium chloride (solid symbols) and 0·50 per cent sodium chloride (open symbols). 5×10^{11} cells/ml.

electrode polarization in the low-frequency region was eliminated by means of the 'movable electrode' method[1b,4].

The bacterial spectra (Fig. 1) resemble those found in other cells[1]. The strong low-frequency band (only partly shown in the figure) complicates the analysis somewhat. Similar bands have been found in other types of cells[1b,5], but their meaning is still obscure[1b,4a]. The presence of the low-conductance surface membrane is indicated by the high dielectric constant of the cells in the frequency-region above this band, and by the band in the high-frequency region. This band represents the effect of the resistance of those elements of the cell and of the surrounding medium, which electrically are in series with the membrane[1a]. This interpretation is supported by a quantitative analysis of the spectra. This analysis, which is a generalization of one described earlier[6], was applied to a series of experiments with different salt concentrations in the suspending medium (0·07–0·6 per cent sodium chloride). This variable controls the resistance of the elements in series with the membrane and hence the spectral position of the band, which showed the theoretically expected shift toward higher frequencies with increasing salt concentration (Fig. 1). A significant point in this analysis is the great width of the high-frequency band, compared with the Debye form, which is explained by the oblong form and heterogeneity in size of the bacteria.

The analysis leads to the conclusion that the dielectric constant of the membrane becomes constant above 1 or 2 Mc./s. The capacity of the membrane in this frequency-region was calculated as that of a perfect insulator in the manner described before[7]. For this purpose, the membrane was assumed to be located at the geometrical surface of the bacterium, as observed microscopically on wet unstained material. The possible presence of cells with transverse membranes was ignored. The value calculated was 0·7 μF., in satisfactory agreement with values of 0·8–0·9 μF. obtained for other cell species (erythrocyte, leucocyte and yeast) in which it was found possible to establish a constant value of the dielectric constant of the membrane in the high-frequency region[8]. The corresponding value for the ratio of the thickness to the dielectric constant of the bacterial membrane is $t_m/\epsilon_m = 13$ A., against earlier values[8] of 10–11 A.

We conclude that the *E. coli* organism possesses a low-conductance surface membrane of approximately the same thickness and dielectric constant as those found in the cell species studied previously. The estimate of 30 A. given above for the thickness of the membrane was based on the assumption that its dielectric constant in the high-frequency region studied is not much above its optical value, which may be taken to be 2·3 (corresponding to a refractive index of 1·5).

This work was supported in part by the U.S. Office of Naval Research (*NR* 119–289) and in part by the U.S. Public Health Service [*H*-1253(*C*)].

HUGO FRICKE
Walter B. James Laboratory for Biophysics,
Biological Laboratory,
Cold Spring Harbor, N.Y.*
HERMAN P. SCHWAN
KAM LI
Medical School and
Moore School of Electrical Engineering,
University of Pennsylvania,
Philadelphia.
VERNON BRYSON
Department of Bacteriology,
Biological Laboratory,
Cold Spring Harbor, N.Y.

Aug. 16.

* Present address: Argonne National Laboratory, Lemont, Illinois.

[1] (*a*) Fricke, H., *J. Gen. Physiol.*, **9**, 137 (1925); Symp. Quant. Biol., Cold Spring Harbor, **1**, 117 (1933). (*b*) Fricke, H., and Curtis, H. J., *J. Gen. Physiol.*, **18**, 821 (1935). (*c*) Cole, K. S., and Curtis, H. J., "Medical Physics", **2**, 82 (Yearbook Publishers, Inc., Chicago, 1950).

[2] (*a*) Shearer, C., *J. Hyg.*, **18**, 337 (1919). (*b*) Brooks, S. C., *J. Gen. Physiol.*, **5**, 365 (1922). (*c*) Green, R. G., and Larson, W. P., *J. Inf. Dis.*, **30**, 550 (1922). (*d*) Zoond, A., *J. Bact.*, **14**, 279 (1927).

[3] (*a*) Schwan, H. P., and Sittel, K., *Trans. Amer. Inst. Elect. Eng.*, 114 (1953). (*b*) Bothwell, T. P., Schwan, H. P., and Wierzinski, F., *Fed. Proc.*, **13**, 15 (1954).

[4] (*a*) Fricke, H., and Curtis, H. J., *J. Phys. Chem.*, **41**, 729 (1937). (*b*) Shaw, T. M., *J. Chem. Phys.*, **10**, 609 (1942). (*c*) Schwan, H. P., *Z. Naturforsch.*, **6b**, 121 (1951).

[5] Fricke, H., and Curtis, H. J., *Nature*, **134**, 102 (1934).

[6] Fricke, H., *J. Phys. Chem.*, **59**, 168 (1955).

[7] Fricke, H., *J. App. Phys.*, **24**, 644 (1953).

[8] Fricke, H., *Nature*, **172**, 731 (1953).

Kinetics of Photosynthesis and Photo-inhibition

THE use of our recording micro-volumeter[1] with reaction vessels of 10 μl. volume or larger and irradiated area 5 mm.² or more allowed the concentration of quite high light intensities on samples of *Chlorella* cells, the rate of oxygen exchange of which was measured. Kinetic studies were made of the limiting photosynthetic reactions and of the inhibitory effects caused by strong light ('solarization').

Experiments with flashing light of mainly two types were carried out: variation of dark-time (t_d, $10^{-3} - 1$ sec.) with a constant time of flash (t_f, 10^{-4} sec. or higher) and variation of time of flash (10^{-4} sec.–1 sec.) with a constant dark-time (5×10^{-2} – 1 sec.). In all cases a sufficiently high light intensity[1] was applied to ensure saturation. We were able to corroborate most of the earlier observations made in this field—which often were apparently inconsistent—and combine the result in a common scheme. A more detailed account of the literature will be given elsewhere.

If very short flashes are alternated with dark periods of increasing length, the yield per flash increases linearly with dark-time during the first few

milliseconds. The rate thus observed equals the saturation-rate in continuous light; that is, photosynthesis continues for a while at full rate after removal of the light and the dark reactions act on a substrate of long life formed in the flash.

If the dark-time is further extended, the yield per flash rises more slowly and ultimately approaches a final value. This maximum yield per flash (for $t_f \to 0$, $t_d \to \infty$ and $I \to \infty$) is independent of temperature and has the value observed by Emerson and Arnold[2]. As was first shown by Kohn[3], the relation between yield per flash and intensity (for $t_f \to 0$, $t_d \to \infty$) is of exponential (first-order) character.

From this we considered that in a brief flash a stable intermediate is produced photochemically in a 'one-quantum' process. In a single flash one light quantum can be stabilized per 150–400 chlorophyll molecules, assuming that 10 quanta are required per oxygen molecule.

If the time of flash is systematically increased (for $t_d \to \infty$), the (saturation) yield per flash initially increases strongly above the value observed with the shortest available flash, and the higher the temperature the faster the increase. Ultimately, the yield per flash increases proportionately with time, and this increase corresponds to the photosynthetic saturation-rate, as observed in continuous light at the prevailing temperature; that is, photosynthesis attains its steady-state rate only after the flash has lasted a definite time.

From this we conclude that in 'long' flashes an additional intermediate between light and oxygen is formed in a dark process. This can be regarded as the charging of an enzyme system. In several cases the time-courses observed in both types of flashing-light experiment can be quantitatively described by a reaction sequence, formally similar to that proposed by Briggs[4]:

$$U \xrightarrow{k_1 I} U^* \qquad (1)$$

$$E + U^* \xrightarrow{k_2 U_0} E^* + U \qquad (2)$$

$$E^* \xrightarrow{k_3} E + \varphi\,(O_2) \qquad (3)$$

U represents a complex of 150–400 chlorophyll molecules arranged around a final acceptor to which an absorbed light quantum is conducted. Excitation of this complex by a light quantum yields a stable product (U^*), which is insensitive to light unless restored in reaction (2). Reaction (3) in turn limits the regeneration of E and is in most types of algae the slower step. The concentration of enzyme E ($E_0 = E + E^*$) is of the same order of magnitude as that of the primary product of photolysis ($U_0 = U + U^*$), $k_3 = 50$–100 sec.$^{-1}$, $k_2 U_0 = 200$–600 sec.$^{-1}$ (at 30° C.).

The above reaction mechanism also describes quantitatively the intensity vs. rate curves as observed in continuous light. A variation of the relative concentrations (E_0/U_0) and time constants ($k_3/k_2 U_0$) involved may account for the variation of the saturation-rate and of the shape of light curves observed in differently pretreated algae.

Additional evidence for the arrangement of pigment molecules in functional units, which are as such involved in the (rate-limiting) photosynthetic dark reactions, was obtained from kinetic studies of photo-inhibition. In very strong light the quantum yield of photosynthesis (φ) decays with a first-order time course, scarcely affected by temperature. This indicates a photochemical inactivation of the pigment system. As soon as the quantum yield is decreased to about half its original value (in some algae even earlier), the saturation-rate in continuous light (R_m) also starts to drop. The time course and the dependence of the decay of both magnitudes on intensity and wave-length are very similar and could in some cases be quantitatively correlated.

We conclude that only one primary solarization reaction occurs, namely, the inactivation of complete pigment complexes. Such a decrease of U_0 will not only lower the quantum yield—since light absorption becomes ineffective—but also the saturation-rate, and this relatively faster the larger the ratio $k_3/k_2 U_0$ in the algae studied. It can be shown from (1)–(3) that the saturation-rate corresponds to:

$$R_m = \frac{k_3 E_0}{1 + k_3/k_2 U_0}$$

Photo-inhibition thus resembles the effect of poisons with so-called narcotic action. Conversely, it will be clear that, following the above picture, all poisons which attack U in preference to E will have 'narcotic' effect. This explains simply the narcotic type of action on photosynthesis which was observed with several 'catalyst poisons'. This suggests that acceptor U contains a heavy-metal system.

The influence of the light intensity on the process of photo-inhibition was further analysed. It appears that in general the half-times of decay are inversely proportional to the square of the applied intensity. From this it follows that the coincidence of two light quanta within a brief time interval may be responsible for the inactivation of a pigment complex. The results show that excited units (U^*) are less susceptible to photochemical destruction than non-excited ones (U).

Details of this work will be published elsewhere in greater detail.

B. Kok
T.N.O. Solar Energy Group
Laboratory of Plant Physiological Research,
Wageningen.

J. A. Businger
Institute for Horticultural Engineering,
Wageningen.

[1] Kok, B., *Biochim. et Biophys. Acta*, **16**, 35 (1955).
[2] Emerson, R., and Arnold, W., *J. Gen. Physiol.*, **16**, 191 (1932).
[3] Kohn, H. J., *Nature*, **137**, 706 (1936).
[4] Briggs, G. E., *Proc. Roy. Soc.*, B, **130**, 24 (1941).

Molecular Weight of Algal Chloroplastin

No recent experimental results are available for the molecular weight of chloroplastin. The available data for chloroplastin have been obtained from leaf extracts (spinach and aspidistra) prepared in a manner similar to that of Smith[1] and calculated from the ultracentrifuge data. Smith[1] and Smith and Pickels[2] found values of the order of 265,000 for chloroplastin; this high estimate is in part due to the contribution of the digitonin micelle. More recently, Takashima[3] made a leaf extract, crystallized a chlorophyll–lipoprotein complex in the cold from α-picolene and determined its molecular weight from diffusion studies to be 19,200. He postulated a complex of two molecules of chlorophyll per molecule of lipoprotein.

Chloroplastin, in the present communication, was prepared from cultures of two algal flagellates,

Table 1. CHLOROPLASTIN (*Euglena gracilis*)

	'Digitonin' extract			'Nacconal' extract		
	(1)	(2)	(3)	(1)	(2)	(3)
w mgm./ml.	29·0	27·3	29·6	44·3	42·5	23·0
w' mgm./ml.	0·37	0·36	0·35	3·1	3·8	0·67
p moles/litre (calculated from equat. 1)	10×10^{-5}	$9·4 \times 10^{-5}$	$10·2 \times 10^{-5}$	$6·4 \times 10^{-4}$	$6·1 \times 10^{-4}$	$3·6 \times 10^{-4}$
p' moles/litre (experimental)	$4·2 \times 10^{-5}$	$6·3 \times 10^{-5}$	$7·7 \times 10^{-5}$	9×10^{-4}	9×10^{-4}	$0·9 \times 10^{-4}$
M^1 gm./mole (ultracentrifuge)	290,000	290,000	290,000	69,400	69,400	69,400
M calculated (from M^1)	43,500	43,500	43,500	10,400	10 400	10,400
M calculated (from nitrogen)	59,000	38,000	30,000	23,000	28,000	50,000

(*Euglena gracilis* and *Poteriochromonas stipitata*). The organisms were concentrated by centrifugation and the centrifuged pellets were ground with sand and 0·9 per cent saline in the cold and recentrifuged twice at 3,000 r.p.m. Each time the pelleted material was discarded. The green supernatant fluid was dried under vacuum. This dried supernatant was extracted either with 2 per cent aqueous digitonin ('Digitonin', $C_{55}H_{90}O_{28}$, non-ionic detergent, *D*-58, Fisher Chemical Co.) or 'Nacconal *NRSF*' (anionic organic detergent–alkyl sulphonate, National Aniline Division, Allied Chemical and Dye Corp.), and these extracts (chloroplastin) were diluted to 1·8 per cent with buffer to *p*H's between 8·0 and 9·2. The pigment concentration, the sedimentation constant, the nitrogen, and the dry weight of the chloroplastin–detergent extracts were determined on freshly prepared material.

The molecular weight of algal chloroplastin was determined by two independent methods. The first was based on the analytical results for the extracted chloroplastin and the second on the geometrical form of the chloroplast, from microscopy.

The molecular weights of the macromolecules may be measured directly by extracting the pigment–macromolecule complex from the chloroplasts by nitrogen-free detergents, 'Digitonin' and 'Nacconal'. The contribution of the macromolecules to the weight of the extracted product may be established by determining the amount of nitrogen in the extract and by employing the assumption that the nitrogen comprised 15 per cent of the protein molecule. If, in addition, it is assumed that each macromolecule is associated with a single pigment molecule, a determination of the pigment concentration permits calculation of the molecular weight of the macromolecule. Alternatively, the molecular weight of the pigment–macromolecule–detergent complex may be determined by analytical ultracentrifugation. From the nitrogen determination, the molecular weight of the pigment–macromolecule may then be calculated directly. The determination of the weight of the complex by analytical ultracentrifugation and the determination of the percentage of nitrogen in the complex provide the best means of determining the molecular weight of the macromolecule.

From the extract, it was possible to obtain: (1) p', the chlorophyll concentration by optical absorption methods; (2) M^1, the molecular weight of the pigment–macromolecule–detergent complex by analytical ultracentrifugation; (3) w, the dried weight of the extract from which the pigment–macromolecule weight could be obtained by subtracting the known contribution of the detergent; and finally (4) w', the nitrogen content of the dried extract. From the analytical data (Table 1) it is also possible to show that one pigment molecule is associated with each macromolecule (lipoprotein; this term is used in preference to lipid layer since it includes the lipids and other macromolecular material as shown by their affinity for osmium tetroxide used in fixation). This is done by demonstrating that the experimentally determined concentration of chlorophyll p' is substantially the same as p calculated from the formula

$$p = \frac{w}{M^1} = \frac{\text{weight of dried residue}}{\text{molecular weight of complex from ultracentrifuge}} \quad (1)$$

The molecular weight M itself is obtained from the assumption that all the nitrogen is in the lipoprotein molecule and that approximately 15 per cent of the lipoprotein weight is nitrogen.

Studies by electron microscopy of the chloroplasts in fixed algal flagellates[4] and isolated chloroplasts from a variety of plant material[5] have shown that the chloroplasts are composed of lamellæ (disks or plates). The electron micrographs of the chloroplasts permit a determination of the number and the dimensions of these layers.

Using the geometrical data from the electron micrographs of the algal chloroplasts, a knowledge of the chlorophyll concentration, and the assumption that the pigment molecules are arranged in monolayers, an estimation of the molecular weight of the pigment–macromolecule (Table 2)[6] can now be made from:

$$M = \frac{\pi D^2 T s L n}{4N} \quad (2)$$

where D is the diameter of the photoreceptor, T is the average thickness of the dense (lipoprotein) layer, s is the density of a protein, L is Avogadro's number, N is the pigment concentration expressed in molecules per photoreceptor and n is the number of dense (lipoprotein) layers.

Table 2. STRUCTURAL DATA OF CHLOROPLAST AND CALCULATED MOLECULAR WEIGHTS

Chloroplast	D, chloroplast diameter (μ)	T, thickness of lipoprotein layers (A.)	n, No. of lipoprotein layers per photoreceptor	N, No. of pigment molecules	M, molecular weight chloroplastin
Euglena gracilis	8·27	242	21	$1·02 \times 10^8$	21,000
Poteriochromonas stipitata	4·15	390	10	$1·10 \times 10^8$	37,000

Molecular weights, *Euglena* chloroplastin, calculated from geometrical considerations alone, and from an independent analytical method, are in good agreement. The average value from twelve determinations in 'Digitonin' is 37,000, and from twelve determinations in 'Nacconal' is 29,000; whereas that from the geometry of the chloroplast is 21,000. For chloroplastin from another alga (*Poteriochromonas stipitata*) an average of 37,000 was obtained from the geometry of the chloroplast.

We have applied the same methods to the retinal rods of the frog and cattle eye[6] and obtained values of the order of 60,000 for frog rhodopsin and 40,000 for cattle rhodopsin, which are similar to recently determined experimental values[7].

J. J. Wolken
F. A. Schwertz*

Biophysical Research,
Laboratory of Molecular Biology,
Eye and Ear Hospital,
University of Pittsburgh School of Medicine,
and
Mellon Institute of Industrial Research,
Pittsburgh, Pa. Sept. 9.

* Present address: Haloid Corporation, Rochester, N.Y.

[1] Smith, E. L., *J. Gen. Physiol.*, **24**, 753, 565, 583 (1941).
[2] Smith, E. L., and Pickels, E. G., *Proc. U.S. Nat. Acad. Sci.*, **26**, 272 (1940).
[3] Takashima, S., *Nature*, **169**, 182 (1952).
[4] Wolken, J. J., and Palade, G. E., *Nature*, **170**, 114 (1952). *Ann. New York Acad. Sci.*, **56**, Art. 5, 373 (1953).
[5] Steinman, E., *Exp. Cell Research*, **8**, 23 (1955). Palade, G. E., *J. Histochem. and Cytochem.*, **1**, 188 (1953).
[6] Wolken, J. J., and Schwertz, F. A., *J. Gen. Physiol.*, **37**, 111 (1953). Wolken, J. J., *J. Cell. and Comp. Physiol.* (in the press). Wolken, J. J., and Schwertz, F. A. (unpublished data).
[7] Hubbard, R., *J. Gen. Physiol.*, **37**, 381 (1954).

Influence of Thyro-parathyroidectomy on the Hæmatological Changes induced by Cortisone in the Rat

The existence of a functional relationship between the adrenal cortex and the thyroid gland has been reported by many workers[1]. In the course of research into the underlying mechanisms responsible for this relationship, the effect of thyro-parathyroidectomy on the blood changes induced by injected cortisone, as indicated by modification of the leucocyte count[2], has been studied.

Twelve female albino rats of the Italico strain of about 250 gm. weight were used for the investigation. Six animals were adrenalectomized and used as controls: the remaining six were thyro-parathyroidectomized and four days later were adrenalectomized. The operations were performed under light ether anæsthesia. Two days later, the animals of each group received a single dose of cortisone acetate (Lepetit) subcutaneously, the dose being calculated on the basis of 2 mgm. per 100 gm. of body-weight. Blood was taken from the tail immediately before the injection of cortisone and thereafter at 3, 24, 48 and 72 hr. The blood films were stained with May–Grünwald–Giemsa's stain.

In the adrenalectomized controls the total leucocyte count showed a slight fall three hours after the cortisone injection, then rose to just above normal and remained at this level from 24 to 72 hr. The mononuclear count showed similar changes. On the other hand, the polymorphonuclear count rose sharply after three hours, then returned to about the normal level after 24 hr.

In the thyro-parathyroidectomized–adrenalectomized rats the total leucocyte count before the cortisone injection was about double that found in the adrenalectomized controls, the mononuclears being increased by about 10,000 and the polymorphonuclears by about 6,500. Three hours after the injection a fall in the total count was recorded and was more marked at 24 hr.; thereafter the total count returned to 'normal' at 48 and 72 hr. after the injection. The mononuclear and polymorphonuclear counts thus showed changes similar to those of the controls, but they were more marked and more prolonged.

The above results show that when adrenalectomy is combined with thyro-parathyroidectomy, the blood changes caused by the injection of cortisone are accentuated and prolonged.

M. P. Brogi
Q. Maggiore

Institute of General Pathology,
University, Pisa. July 18.

[1] Deane, H. W., and Greep, R. O., *Endocrin.*, **41**, 243 (1947). Freedman, H. H., and Gordon, A. S., *Proc. Soc. Exp. Biol. and Med.*, **75**, 729 (1950). Hill, jun., S. R., Reiss, R. S., Forsham, P. H., and Thorn, G. W., *J. Clin. Endocrinol.*, **10**, 1375 (1950). Money W. L., Kirschner, L., Kraintz, L., Merrill, P., and Rawson, R. W., *J. Clin. Endocrinol.*, **10**, 1282 (1950).
[2] Nelson, D. H., Sandberg, A. A., Palmer, J. G., and Thyler, F. H., *J. Clin. Invest.*, **31**, 843 (1952). Bacchus, H., *Endocrin.*, **54**, 402 (1954).

Table 1. Leucocyte Counts in Six Adrenalectomized and Six Thyro-parathyroidectomized–Adrenalectomized Rats after Injection of Cortisone Acetate

No. of leucocytes (thousands per c.mm.)	Adrenalectomized controls					Thyro-parathyroidectomized–adrenalectomized animals				
	Before injection of cortisone	Hours after injection of cortisone				Before injection of cortisone	Hours after injection of cortisone			
		3	24	48	72		3	24	48	72
Total number of leucocytes	16	14	17	17	18	32·5	29	27	32	32
Mononuclear count	15	11*	16	15	17	25	15*	15*	21	22·5
Polymorphonuclear count	1·3	3·3*	1·4	1·2	1	8	14*	12*	11*	9·5*

* Difference from values before injection statistically significant (Student's t test; $P < 0.05$)

Plasma Protein as a Precursor of Rat Liver and Hepatoma Protein

While there is little evidence that one protein can be converted into another without complete degradation to amino-acids in the tissues of normal animals (see Askonas *et al.*[1]), there is some evidence that such an interconversion of proteins can occur in tumour tissue. Thus Babson and Winnick[2] showed that the Walker rat-carcinoma incorporated amino-acids from injected plasma protein without complete hydrolysis of the latter to free amino-acids. Recently, Busch and Greene[3] have demonstrated a more rapid uptake of amino-acids derived from plasma protein by implanted tumour tissue than by normal tissue. In these experiments the uptake by the tissues of injected free amino-acids served as a control.

In order to determine whether this phenomenon is a characteristic of tumours, the incorporation of amino-acids derived from injected serum albumin into the proteins of liver and hepatoma has been studied in the rat.

A rat (340 gm.) was injected intraperitoneally with 50 μc. of L-^{14}C-lysine and killed after 6 hr. The plasma was fractionated by the method of Campbell and Stone[4] to give a purified preparation of radioactive albumin. A rat (310 gm.) bearing several discrete hepatomas produced by feeding 4-dimethyl-aminoazobenzene was intravenously injected with 150 mgm. of the ^{14}C-lysine-albumin (equivalent to 0·4 μc.) in 3 ml. of saline together with 20 μc. of L-^{14}C-

alanine (1·0 mgm.). After 95 min., the rat was killed and the liver perfused with saline. The hepatoma tissue was separated from the unaffected lobes of the liver, and saline extracts containing the soluble proteins were prepared from the homogenized tissues.

After precipitation with trichloroacetic acid, the protein was hydrolysed with 5 *N* hydrochloric acid and the amino-acids were separated by ion-exchange chromatography (Hirs *et al.*[5]). The specific radioactivity of the lysine and alanine from each protein fraction was determined after conversion of the amino-acids to their dinitrophenyl derivatives. The ratio of the specific radioactivity of alanine to lysine from the hepatoma protein was 9·8 and from the liver 10·3.

Since the radioactive lysine in the tissue proteins was derived from plasma protein and the radioactive alanine from the pool of free amino-acids, these results suggest that amino-acids derived from injected serum albumin are not incorporated into the soluble proteins of hepatoma tissue to a greater extent than into those of liver tissue.

In order to make this a firm conclusion, two requirements remain : (*a*) that the size of the pools of alanine and lysine are approximately the same in the two tissues ; (*b*) that the presence of radioactive serum albumin in the tissue extracts does not materially alter the ratio of the radioactivity of alanine to lysine. Determination of the amounts of albumin in the extracts by precipitation with an antiserum for serum albumin[6,7] showed that, in fact, 8·4 per cent of the soluble protein from hepatoma, and 4·0 per cent of that from the liver, consisted of serum albumin. In view of this, experiments designed to provide more conclusive evidence on this point are proceeding.

This study will be extended to include tissues other than liver and hepatoma and plasma proteins other than albumin. We thank Prof. F. Dickens for his interest, and the British Empire Cancer Campaign for a grant to the Middlesex Hospital Medical School which covered the cost of the work.

P. N. Campbell
H. E. H. Jones
Nancy E. Stone

Courtauld Institute of Biochemistry,
Middlesex Hospital Medical School,
London, W.1.
Nov. 11.

[1] Askonas, B. A., Campbell, P. N., Godin, C., and Work, T. S., *Biochem. J.*, **61**, 105 (1955).
[2] Babson, A. L., and Winnick, T., *Cancer Res.*, **14**, 606 (1954).
[3] Busch, H., and Greene, H. S. N., *Yale J. Biol. and Med.*, **27**, 339 (1955).
[4] Campbell, P. N., and Stone, N. E., *Biochem. J.*, Proc. 345th Meeting.
[5] Hirs, C. H. W., Moore, S., and Stein, W. H., *J. Amer. Chem. Soc.*, **76**, 6063 (1954).
[6] Campbell, P. N., and Stone, N. E., *Biochem. J.*, [**61**, xx (1955)].
[7] Campbell, P. N., *Biochem. J.*, **61**, 496 (1955).

Electrical Responses of Certain Lepidopterous Tympanal Organs

Although from a variety of behaviour work[1-3] there must be a strong presumption that the tympanal organs of certain night-flying moths respond to airborne sounds, hitherto no direct physiological evidence on this point has been forthcoming. We have recently been able to record electrical responses in the tympanal nerves of certain moths in response to stimulation by airborne sounds, and these preliminary experiments have revealed certain features of interest in the responses of the organs.

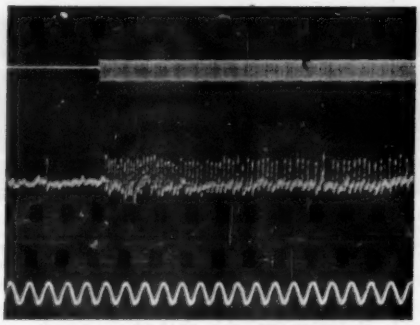


Fig. 1. Response in tympanic nerve of *Arctia* (middle trace) to pure tone stimulus of 3·5 kc./s. (upper trace). Timing wave, 50 c./s. (lower trace)

The insects used were the buff tip moth, *Phalera bucephala* L. (Notodontidae), and the garden tiger moth, *Arctia caja* L. (Arctiidae). The nerve preparations were made by clearing the mesoscutum of scales, cutting a window in the cuticle, dissecting away the overlying tissues to reveal the pterothoracic ganglion and tracing the compound nerve which serves some of the flight muscles and the tympanal organ. The branch serving the latter leaves the main trunk near the wall of the lateral air sacs ; it is thin and susceptible to desiccation, especially when severed from the main nerve, and therefore recording was done by placing two platinum wire electrodes on the nerve *in situ*. Since the nerve serving the tympanal organ is itself a mixed nerve, the records are marked in almost every case by large spikes derived from the motor fibres present.

Recording under conditions of zero stimulation showed that no resting discharge was present ; this is in contrast to other invertebrate hearing organs where, as Pumphrey[4] points out, all those so far investigated show this phenomenon. The moth tympanal organs responded to pure tone stimuli in the range 3–20 kc./s., the limit of the apparatus, and Fig. 1 shows the discharge in the tympanic nerve of *Arctia* to a stimulus of 3·5 kc./s. ; the response is asynchronous and shows no equilibration. Threshold measurements were not taken, but using the human ear as a standard the preparations were much more sensitive to high frequencies of the order of 16–20 kc./s. No apparatus for generating ultrasonic stimuli was available, but the preparations were very sensitive to the squeaks of a bottle top, which contain very high frequencies, and responded to such noises over a distance of 24 ft. Fig. 2 shows the responses in

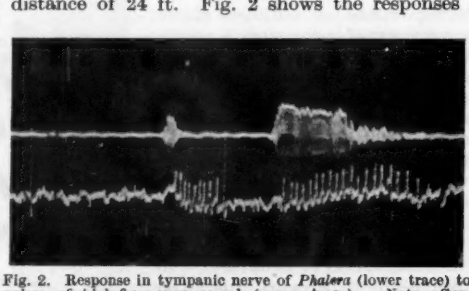


Fig. 2. Response in tympanic nerve of *Phalera* (lower trace) to pulses of high-frequency sound (upper trace). Note after-discharge and recurrent motor spikes in nerve record

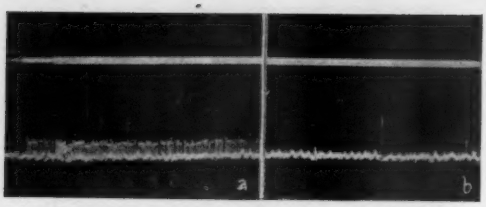


Fig. 3. Responses in tympanic nerve of *Arctia* (lower trace) to pure tone stimulus of 3 kc./s. (upper trace). (*a*) Onset of stimulus and nerve response; (*b*) the same record after 6 sec., showing only one motor spike

the tympanic nerve of *Phalera* obtained with such stimuli. It seems probable that the upper frequency limit of the tympanal organs is very high, extending well into the ultrasonic range, as in some Orthoptera.

One of the most interesting features of the responses of these organs was the adaptation shown to a constant stimulus, consisting of the reduction in frequency of the discharge from an initial high rate (Fig. 3*a*) to zero when the stimulus was maintained for 6 sec. or longer (Fig. 3*b*). That this was true adaptation and not fatigue was shown by the fact that a change in the intensity of the stimulus produced an increased discharge in the nerve. Such adaptation has not been found in any other invertebrate hearing organs so far investigated; it explains some of the observations of previous workers[2] that Noctuid moths remain unaffected by loud, continuous noises.

Response to high-frequency sounds of short duration also showed pronounced after-discharge (Fig. 2). The duration of the after-discharge was such as to make it probable that the appearance of volleys of spikes synchronous with the pulse or modulation frequency of the stimulating sound would only occur at modulation frequencies up to 45 c./s., a much lower figure than that obtaining in Orthoptera[5] or in Homoptera[6]. If the frequency of modulation exceeds this figure, the discharge first becomes continuous, and then ceases through adaptation, provided the stimulus continues long enough.

These preliminary findings suggest that the tympanal organ in these moths will respond to short pulses of high-frequency sound repeated at rates up to 45 c./s. with a volley of spikes for each pulse, but that continuous noise or sounds consisting of rapidly repeated pulses will produce adaptation and ultimately cessation of the discharge. This suggestion may be considered against the background of two hypotheses on moth behaviour in relation to auditory stimuli. Hinton[7] has proposed that night-flying moths may make use of echo-location to avoid obstacles, in the same manner as bats; the characteristics of the hearing organs as outlined above are very suitable for such a mechanism, but it has yet to be demonstrated that moths emit ultrasonic pulses. The second hypothesis, apparently first advanced by Richter[8] in 1909, is that night-flying moths avoid their typical predators (owls and bats) by taking flight in response to high-pitched sounds of short duration—characteristics of the cries of these animals. The little observation of behaviour that exists seems to support this latter view; Schaller and Timm[2] have shown that certain night-flying moths take flight or feign death on exposure to ultrasonic frequencies between 40 and 80 kc./s., and point out that this range includes those frequencies found in the cries emitted by bats. The present findings suggest a basis for further work in this connexion that might be more rewarding.

P. T. Haskell
P. Belton

Department of Zoology and Applied Entomology,
Imperial College Field Station,
Silwood Park,
Sunninghill, Berkshire.
Aug. 25.

[1] Eggers, F., *Z. vergl. Physiol.*, **2**, 297 (1925).
[2] Schaller, F., and Timm, C., *Z. vergl. Physiol.*, **32**, 468 (1951).
[3] Turner, C. H., and Schwarz, E., *Biol. Bull.*, **27**, 275 (1914).
[4] Pumphrey, R. J., *Symp. Soc. Exp. Biol.*, **4**, 1 (1950).
[5] Pumphrey, R. J., and Rawdon-Smith, A. F., *Nature*, **143**, 806 (1939).
[6] Pringle, J. W. S., *J. Exp. Biol.*, **31**, 525 (1954).
[7] Hinton, H. E., *Proc. Roy. Ent. Soc. Lond.*, (C), **20**, 5 (1955).
[8] Richter, O., *Int. Ent. Z.*, **3**, 124 (1909).

Chromosomes of Five Rodent Species

Satisfactory cytogenetic studies with existing laboratory mammals are at present virtually impossible owing to the large number and small size of their chromosomes. A small eutherian which could be bred in the laboratory and which had few, relatively large, chromosomes would be invaluable. Matthey's[1] recent count of $2n = 17$ in the fossorial vole, *Ellobius lutescens*, and the earlier report of $2n = 14$ in the South African insectivore *Elephantulus myurus*[2] (which, however, is questioned by Matthey[3]) encourage the hope that a suitable species may yet be found. Only about 120 rodent species, representing forty-nine of the 345 genera listed by Ellerman[4], have been studied cytologically. We have therefore examined the chromosomes of five African species which we have been able to obtain from laboratories in Great Britain.

Young males were used where possible. All animals were given an intraperitoneal colchicine injection (0·6–1·0 ml. of 0·1 per cent or 0·05 per cent aqueous solution) two hours before killing. The testes were cut up and put into distilled water or hypotonic saline for 5–30 min. before fixing in acetic-alcohol (1 : 3) for two hours, hydrolysing in *N* hydrochloric acid at 60° C. for 6–12 min., and staining in the Feulgen reagent. Squashes of short pieces of tubule

Fig. 1. *Saccostomus campestris*. Spermatogonial metaphase, $2n = 44$. Fig. 2. *Rattus natalensis*. Precociously condensed sex bivalent at pachytene. Fig. 3. *Saccostomus campestris*. Group of associated chromosomes at pachytene. All × 1,600

Table 1

Species	No. of animals	Chromosome No. n	Chromosome No. 2n	Range of chromosome length
Rattus (*Mastomys*) *natalensis*, A. Smith	2	18	36	2·2 μ–9·0 μ
Mystromys albicaudatus, A. Smith	1	16	32	1·1 μ–4·7 μ
Meriones lybicus, Lichtenstein	3	22	44	1·3 μ–4·0 μ
Lemniscomys barbarus, L.	2	27	54	0·7 μ–2·8 μ
Saccostomus campestris, Peters	1	22	44	1·0 μ–4·0 μ

were made, sometimes after additional staining in aceto-carmine or aceto-orcein. Skins and skulls of the animals killed were submitted to Mr. R. W. Hayman, of the British Museum (Natural History), who kindly checked their identity.

Counts obtained at diakinesis or metaphase in primary spermatocytes, and at spermatogonial metaphase, are given in Table 1. Measurements made of the shortest and longest chromosomes in well-spread spermatogonial metaphases, one from each species, are also entered in the table. They are intended to give a rough estimate only of size and range of variation, and in any event are likely to be somewhat less than normal owing to the action of the colchicine. The numbers given for the first four species confirm counts obtained by Matthey[5,6] in papers which reached us after the work had been completed. The chromosomes of *Saccostomus campestris* (Fig. 1) have not been examined previously, so far as we know.

Although the main object was to determine chromosome number and size, two additional observations are worth recording. The presence of a prominent unpaired interstitial loop in the precociously condensed sex bivalent of *R. natalensis* at pachytene (Fig. 2) strongly suggests the presence of an intercalary differential segment such as Koller[7] has inferred to be present in the sex chromosomes of the cat. In *S. campestris* prominent darkly staining regions in the pachytene chromosomes regularly fuse together (Fig. 3), sometimes into more than one group, the arms radiating outwards like the spokes of a wheel and calling to mind the chromocentre and attached chromosome arms in the salivary gland nuclei of *Drosophila melanogaster*.

Chromosome counts on mammals can now be obtained quickly and accurately; the techniques are simple, and it is part of the purpose of this communication to encourage others to use them. Meanwhile we would be glad to examine the chromosomes of other, cytologically unknown, rodents or insectivores if material is sent to us. Although we are primarily concerned with finding a mammal with low chromosome number for experimental purposes, chromosome counts themselves may help to reveal biological situations of wider interest. For example, the recent counts made by Wahrman and Zahavi[8] indicate that the taxonomic species *Gerbillus pyramidum* in the Mediterranean area is a complex of several distinct chromosome races.

We are indebted to Mr. M. K. Totton, of the London School of Hygiene and Tropical Medicine Field Station, St. Albans, for *Rattus natalensis* and *Mystromys albicaudata*; to Dr. F. J. Aumonier, of St. Bartholomew's Hospital Medical School, for *Meriones lybicus*; and to Mr. O. G. Jones and the Zoological Society of London for *Saccostomus campestris* and *Lemniscomys barbarus*.

Note added in proof. We find $n = 15$, $2n = 30$, in testis material of *Elephantulus myurus* fixed in South Africa and sent to us through the kindness of Prof. B. I. Balinsky.

C. E. Ford
J. L. Hamerton
Medical Research Council
Radiobiological Research Unit,
Atomic Energy Research Establishment,
Harwell, Berkshire. Sept. 16.

[1] Matthey, R., *Experientia*, **10**, 18 (1954).
[2] Brenner, S., *S. Afr. J. Med. Sci.*, **11**, Biol. Supp. 71 (1946).
[3] Matthey, R., *Rev. Suisse Zool.*, **61**, 669 (1954).
[4] Ellerman, J. R., "The Families and Genera of Living Rodents" (London, 1940–49).
[5] Matthey, R., *Caryologia*, **6**, 1 (1954).
[6] Matthey, R., *Experientia*, **8**, 389 (1952).
[7] Koller, P. C., *Proc. Roy. Soc. Edin.*, B, **61**, 78 (1941).
[8] Wahrman, J., and Zahavi, A., *Nature*, **175**, 600 (1955).

Cytoplasmic Inheritance in *Culex*

From an analysis of non-reciprocal fertility in *Aëdes scutellaris*, Smith-White and Woodhill[1] drew the conclusion that this phenomenon must be due either to anomalous meiosis in the course of oogenesis, with polarized segregation of bivalents and the elimination of part of the paternal genom, or to cytoplasmic factors acting independently of the nucleus. They state that "There is no critical evidence enabling a choice between the two types of hypothesis". Crossing relations in *Aëdes scutellaris*, as studied by Smith-White and Woodhill, are essentially similar to the more complex relations encountered in the *Culex pipiens* complex[2]. Some geographically representative populations are fully fertile in both directions, whereas others, although morphologically indistinguishable, are almost completely isolated by intersterility. In this case the limitations of a purely morphological species concept are obvious. A third group of populations is interfertile with the others in one direction only. Parthenogenesis, with pseudogamy, predetermination and multiple incompatibility genes can be excluded as causative mechanisms. These cases of strictly maternal inheritance can be explained only by the two hypotheses mentioned by Smith-White and Woodhill.

Further evidence is now available which may make possible a choice between the two hypotheses. Mutations induced by X-rays have been produced in *Culex pipiens*, and the mutant genes have been introduced into other populations with the view of studying their mode of inheritance. A description of some of these mutations is given elsewhere[3]. They are mostly clear-cut morphological characters affecting the antennæ, palps and wing venation. Four of them, at least, can be used to mark the two autosomes and the male and female sex chromosomes respectively. All of them segregate in clear-cut Mendelian ratios. There is no indication of polarized segregation (Table 1). Similar ratios are obtained on out-crossing to other populations. Thus the ratio obtained from the cross $+/+ \times Rap/+$, using the strains *O* (southern Germany) and *Alg* (Algiers), which can cross only in the direction ♀ *Alg* × ♂ *O*, is 147 : 143, = 1 : 1. Using the same strains, the cross $+/kps \times +/kps$ gives the ratio 253 : 81, which is 3 123 : 1. It will be seen that, in *Culex*, there is no evidence of abnormal behaviour of the chromosomes at meiosis and only the cytoplasmic hypothesis therefore remains.

An experiment now running in the forty-fourth back-cross generation seems to make possible a

Table 1. Mutations in *Culex pipiens*

Gene	Location	Status	Cross	Segregation in next generation	Ratio
kps	Autosomal (I)	Recessive	+/+ × *kps*/*kps*	All phenotypically normal	—
			+/*kps* × +/*kps*	178 normal : 56 *kps*	3·178 : 1
*Rap**	Autosomal (II)	Dominant	+/+ × *Rap*/+	331 normal : 332 *Rap*	1 : 1
var	Sex-linked with ♀	Recessive	+*M*/var. *m* × var. *m*/var. *m*†	All ♂♂ normal, all ♀♀ var.	—
Kpu	Sex-linked with ♂	Dominant	*Kpu M*/+*m* × +*m*/+*m*	All ♂♂ *Kpu*, all ♀♀ normal	—

* Homozygous lethal.
† *M* = ♂ sex-determining factor; *m* = ♀ sex-determining factor (ref. 4).

further distinction. Cytoplasmic inheritance may be independent of the nucleus with autonomous plasmagenes, or it may depend on nuclear cytoplasm-conditioning genes. Assuming normal meiosis, repeated incrossing of a foreign genom *B* into a given strain *A* can be made to result in replacement of genom *A* by genom *B*. A character independent of the nucleus of strain *A*, controlled by the cytoplasm, will not be affected by this change of genom. This is precisely the case in a long-running crossing experiment with strains *H* (northern Germany) and *O* (southern Germany). In every generation the hybrid (*H* × *O*) female was back-crossed to *O* males. After forty-four serial back-crosses of this kind, it may be presumed that the original genom *H* will have changed wholly or largely to *O*. Nevertheless, the mating type of the hybrid shows no change, that is, the hybrid males remain intersterile with *O* females, as in the original strain *H*.

Hannes Laven

Max-Planck-Institut für Biologie,
Tübingen.
Aug. 22.

[1] Smith-White, S., and Woodhill, A. R., *Proc. Linn. Soc. N.S.W.*, **79**, 163 (1954).
[2] Laven, H., *Evolution*, **5**, 370 (1951); *Z. ind. Abst. Vererb.*, **85**, 118 (1953).
[3] Laven, H., *Proc. Roy. Ent. Soc. Lond.* (in the press).
[4] Gilchrist, B. M., and Haldane, J. B. S., *Hereditas, Lund*, **33**, 175 (1947).

Influence of Temperature on the Histological Evolution of the Ovotestis of *Cepea nemoralis* L.

The conditions which determine the differentiation of indifferent gonocytes in hermaphrodite glands, either in the male or the female direction, constitute a major problem in the biology of sexuality. Ancel[1] showed in 1902 that in the ovotestis of pulmonates the differentiation of germinal cells was independent of the gonocytes, but depended on the appearance of nutritive cells. Ancel remarks: "Une cellule progerminative indifférente deviendra mâle ou femelle suivant les conditions qu'elle rencontre dans la glande génitale au moment de son apparition, conditions réglées par la transformation d'un certain nombre de cellules épithéliales en éléments nourriciers élaborateurs d'un matériel spécial". But experiments with undifferentiated strains of *Rana fusca* and *Rana sylvatica* (Witshi, Piquet[2,3]) have indicated that several factors, and more especially temperature, can condition gametogenesis.

Witshi and Piquet have pointed out that at an elevated temperature (30° C.) one obtains only males. Some are genotypically males, the others are inverted females. The female differentiating agent situated in the cortical part of the gland regresses whereas the medulla develops. The male differentiating agent then becomes preponderant. At low temperatures the opposite happens. The differentiation of gonocytes towards oogenesis or spermatogenesis appears here as a result of conditions prevailing outside the gonocytes, in this case in the cortex or medulla of the gonad.

It seemed interesting to me to follow the evolution of the ovotestis of Pulmonata at different temperatures. This work was carried out in the Zoology Laboratory of the University of Brussels, under the direction of Prof. P. Brien, to whom I am greatly indebted.

My observations were made on the snail *Cepea nemoralis* L. Four groups of animals were set up. The first three were kept at temperatures of 0°, 6° and 23° C., respectively.

The animals of the fourth group were reared in conditions approaching as nearly as possible those prevailing in hibernating animals; they were used as controls. For this group the average monthly temperature was established throughout the experiment as follows: November, 7·0°; December, 2·8°; January, 1·7°; February, 1·3°; March, 6·8°; April, 13·5°; May, 19·0° C.

At regular intervals during a period of seven months, the ovotestis was taken from a number of animals of each series and a study was made of their histology. A summary of the results follows.

(1) Low temperatures of approximately 0° C. inhibit all gametogenesis—both oogenesis and spermatogenesis.

(2) At a slightly higher temperature, 6° C., the development of male germinal cells is inhibited. In the meantime, oogenesis begins and proceeds at a higher rate than in the corresponding controls. The observations did not cover sufficient time to allow me to conclude whether spermatogenesis was definitely inhibited, or whether it was only slowed down.

(3) Controls influenced by seasonal environmental variations showed all aspects of gonad evolution, namely: (*a*) a period of no sexual development corresponding to the first months of hibernation (October to February); (*b*) oogenesis (March to April) including formation of oocytes (a fact already noted by Laviolette[4] in *Arion rufus*), which slowly increase in size; (*c*) spermatogenesis (April to May); this being much faster than oogenesis, the sperm will be ripe before the oocytes, the animal acting first as male then as female.

(4) A higher temperature (23° C.) promotes and maintains spermatogenesis, but without completely inhibiting oogenesis: a few oocytes differentiate but maturation does not follow.

It is concluded that temperature has an effect on sexual differentiation in the Pulmonata. A low temperature is more favourable to development of primary gonocytes in the female direction; and a high temperature promotes development in the male direction.

These results are similar to those obtained by Witshi on frogs; but in the case of the Pulmonata, hermaphrodite animals having a germinal epithelium ensuring simultaneously the elements of male and female germ cells, it remains to be shown at what

level external factors such as temperature can act to influence sexual differentiation in one direction or the other.

J. Bouillon

Laboratoire de Zoologie,
Université Libre de Bruxelles,
Avenue Franklin Roosevelt,
Brussels.

[1] Ancel, *Arch. Biol.*, **19**, 390 (1902).
[2] Witschi, *Arch. f. Mikr. Anat.*, **85** and **86** (1914); *J. Exp. Zool.*, **52** (1929).
[3] Piquet, *Rev. Suisse Zool.*, **37** (1930).
[4] Laviolette, *C.R. Soc. Biol., Paris*, **144** (1950).

Photostimulation of an Equatorial Bird (*Quelea quelea*, Linnæus)

Few data are available concerning the environmental factors involved in the 'timing' of the reproductive cycles of equatorial birds. The annual fluctuation of day-length on the equator is only about two minutes. Wolfson[1,2], considers it possible that "summation of daylengths or the daily dose of light", rather than increasing day-lengths as such, might be the critical environmental factor in determining the periods of migration and breeding of equatorial, as well as other, species.

Attempts to photostimulate tropical birds have been rare, and the results confusing. Scott and Payne[3] exposed guinea-fowl to additional illumination in the United States and ascribed the lack of response in this species to its tropical origin. On the other hand, Brown and Rollo[4] and Rollo and Domm[5] showed that the cycles of a variety of tropical whydahs and weavers (purchased in California) were modifiable by photoperiodicity.

Quelea quelea (Sudan Dioch), the weaver-bird used in the present experiment, ranges transequatorially over a vast area of the drier regions of Africa. In Tanganyika it nests colonially after rainfall. It is strongly nomadic and so an East African flock, sometimes several millions strong, may cross and re-cross the equator in search of food, and thus be temporarily exposed to either a minute increase, or decrease, in day-length according to its wanderings and the period of the year.

The present birds were trapped at about latitude 3·22° S. and were habituated to the aviary for more than a year, when the males were moulting out of the vivid breeding plumage into eclipse, and becoming indistinguishable from the dull-coloured females.

The normal breeding season in northern Tanganyika is in May or June provided that rain has fallen and conditions are favourable for nesting. At this period, day-length is diminishing at a rate of only seconds per day in the area in which our birds were collected. In other areas within a few hundred miles, reproduction occurs when days are slowly increasing in duration. Our experiment was begun on July 23 (day-length approximately 11 hr. 57 min.) at about the estimated end of the post-nuptial refractory period and before the next season's spermatogenesis began.

Forty-four individuals in or near eclipse plumage were divided into two groups of seventeen, and one of ten. These were placed in three almost identical cages with a diet of wheat, weed-seeds and water. The cages were of approximately 12 cu. ft. capacity; experience has shown that *Q. quelea*, accustomed to congregating in hundreds within a few feet, thrives in close confinement. The experiment was ended on September 17 (day-length approximately 12 hr. 5 min.) after being conducted as follows.

Cage 1. Ten control birds, under normal day-length.

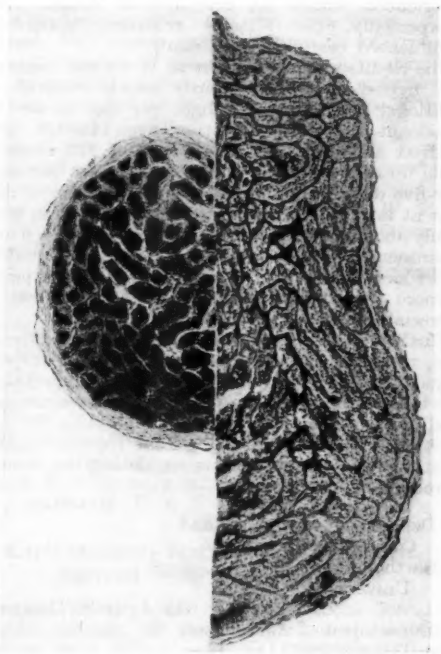
Cage 2. Seventeen experimental birds illuminated by a single 100-watt bulb 5 ft. from cage for five minutes daily at dusk (about 7 p.m.).

Cage 3. Seventeen experimental birds similarly illuminated from about 7 p.m. to midnight and receiving, therefore, an additional five hours light, making a total of more than seventeen hours of daily illumination. (These usually, however, appeared to be asleep by 10 p.m.)

The results were as follows.

Cage 1. (Controls, which were found to be five males and five females.) Each male had testes measuring 1 mm. × 1 mm. in diameter. In all birds the seminiferous tubules were still in a state of post-nuptial lipophanerosis in varying degree. The interstitium remained in a meagrely lipoidal condition[6] (Fig. 1*A*). The tubules in each case were 35μ in diameter, measured in the wax-embedded section. Each of the five females had oocytes invisible or only just visible to the naked eye.

Cage 2. (Plus 5 min. daily. The birds were found to be five males and thirteen females.) Each male had testes measuring 1 mm. × 1 mm. in diameter (similar to those of the controls) except one in which the dimensions were 2 mm. × 1 mm. and 1·5 mm. × 1·5 mm. In the tubules of each organ there



(*A*) (*B*)

Fig. 1. Photostimulation of *Quelea quelea* showing changes in size and internal arrangement of testes. *A*, Testis appearance in control birds and those subjected to five minutes additional day-length over a period of fifty-five days. The seminiferous tubules are still in the post-nuptial lipoidal condition (indicated by black material) and the interstitium remains undeveloped. *B*, Testis appearance of birds subjected to an additional day-length of five hours for fifty-five days. A lipoidal interstitium has developed (indicated by black material) and the tubules have cleared. (Formal-calcium fixation, sudan-black coloration at 7μ. × 53)

remained uncleared post-nuptial lipids (as in Fig. 1*A*), although only faint traces remained in the slightly enlarged tubules of the exceptional organ. The tubules of the smaller testes were of similar diameter to those of the controls. Those of the largest testes measured nearly 45μ in diameter, the increased dimensions being caused by a slight proliferation of spermatogonia. The interstitium was in each case similar to that of the control birds. Each of the thirteen females had ovaries in the same condition as those of the control group.

Cage 3. (Plus 5 hr. daily. The birds were found to be six males, ten females and one intersex.) Each normal male had testes enlarged to between 2 mm. × 1·5 mm. and 2·9 mm. × 2·3 mm. except one in which they were 1 mm. × 1 mm. in diameter. In all enlarged organs the increase in size was due to the production of several rows of spermatogonia resulting in tubule expansion up to 50μ. Post-nuptial lipids had been cleared (Fig. 1*B*). In the exceptionally sized organs the tubule diameter was only 35μ; but the tubules were almost clear of lipids. In all cases the Leydig cell cytoplasm of the interstitium had become sprinkled with lipid droplets. Each of the ten females had ovaries in the same condition as those of the two former groups.

The above results show that near the end of their post-nuptial testis metamorphosis, the males of this equatorial weaver-finch are susceptible to photostimulation making up a total daily illumination of about seventeen hours—a period not naturally experienced within its geographical range. Not unexpectedly, the females remained apparently uninfluenced (see also Whetham[7]).

The results give no support to Wolfson's "summation hypothesis". The birds which received an additional five minutes of light per day showed no significant gonad modification even though they received an additional grand total of 275 minutes, made up of five-minute increments over a period of fifty-five days. The normal annual variation of daylight at latitude 3·22° S. (at which these birds bred) is only about ten minutes. We subjected our + 5 min. experimental birds to artificial 'summation' equalling that which would be normally received over a period of more than twenty-seven years. There was no appreciable result.

Further experiments with *Q. quelea* of different ages, involving various light increments at different periods of the sexual cycle, are being undertaken. We believe, however, that it is the environmental conditions arising after rainfall, operating in conjunction with the internal sexual rhythm[6,8], that constitute the critical factors regulating the time of reproduction.

A. J. Marshall

Department of Zoology and Comparative Anatomy,
St. Bartholomew's Medical College,
University of London.

H. J. de S. Disney

Department of Agriculture,
Tanganyika. Dec. 12.

[1] Wolfson, A., *Sci. Mon.*, **74**, 191 (1952).
[2] Wolfson, A., *Condor*, **55**, 187 (1953).
[3] Scott, H. M., and Payne, L., cited by Marshall, F. H. A., *Biol. Rev.*, **17**, 68 (1942).
[4] Brown, F. A., and Rollo, M., *Auk*, **57**, 485 (1940).
[5] Rollo, M., and Domm, L. V., *Auk*, **60**, 357 (1943).
[6] Marshall, A. J., *Quart. J. Micro. Sci.*, **90**, 265 (1949).
[7] Whetham, E. O., *J. Agric. Sci.*, **23**, 383 (1933).
[8] Marshall, A. J., "Reproduction in Male Birds". Chapter in "The Comparative Endocrinology of Vertebrates" (London, 1955).

Yield Stress of Clay–Water Systems

I have shown elsewhere[1] that the variation of specific viscosity (η_{sp}) with solid content (c) for concentrated sodium montmorillonite sols follows the Schultz–Blatschke relation[2] for systems of anisometric particles:

$$\eta_{sp} = [\eta]c + k'[\eta]^2c^2 + k'[\eta]^3c^3 \qquad (1)$$

$[\eta]$, the 'intrinsic viscosity', depends on the dissymmetry (p) of the dispersed and solvated clay platelets; while k' represents the particle–particle interaction at unit dissymmetry. At any sol concentration, $\bar{\eta}_{sp} = \eta_{sp} - c[\eta]$ will thus measure the contribution of this latter factor to the specific viscosity.

The precise interpretation of 'yield value' or 'yield stress' in clay sols is still a subject for speculation; but most theories approximate to the view that this property defines the shearing stress, at which the internal attractive forces between the dispersed particles have been overcome, and laminar flow prevails. One may thus expect the optimum yield stress (S) of a clay–water system to depend on some simple function of the particle interaction as expressed by $\bar{\eta}_{sp}$, and

$$S \text{ should equal } f(\bar{\eta}_{sp}) \qquad (2)$$

I have investigated the rheological properties of sols prepared from American, English and Mediterranean sodium and sodium–calcium montmorillonites, and kaolinites, under different experimental conditions; and have plotted the yield stress in terms of the property $\bar{\eta}_{sp}$. The Stormer viscometer has proved to be a satisfactory instrument for measuring both the optimum yield stress and the specific viscosity at low shear (corrected for the initial yield stress) over a wide range of conditions. Some typical results from these investigations are presented in this communication.

The variation of yield stress with particle interaction in any particular system is determined by the state of peptization or coagulation of the clay micelles. Sodium montmorillonite sols, when prepared in distilled water, exhibit the phenomenon of 'heterocoagulation' (that is, positively charged edges are orientated perpendicular to the negative faces of the clay platelets); and the results for sols prepared from a series of such clays of similar B.E.C. (80–90 m.equiv./100 gm.) but of different particle shape are presented in Fig. 1. (The ultimate particle size as determined by sedimentation techniques is in all cases of the order of 0·1 micron.)

At $\eta_{sp} \ll c[\eta]$, the yield stress is negligible, even after standing for 72 hr. With increasing η_{sp}, S rises rapidly and the following relation has been observed over a wide range of sol concentration and particle dissymmetry:

$$S = g\bar{\eta}_{sp}^2 \qquad (3)$$

The values of g increase in the order: clay D (Cyprus sodium montmorillonite) < clay C (English sodium montmorillonite) < clay F (North African sodium montmorillonite) < Wyoming bentonite; while Wyoming bentonite > hectorite. The first three were prepared from the corresponding natural calcium clays by interaction with sodium carbonate[1].

These values of g are related to the shape of the dispersed clay particle as demonstrated by their electron micrographs[3]. The strongest gels at a

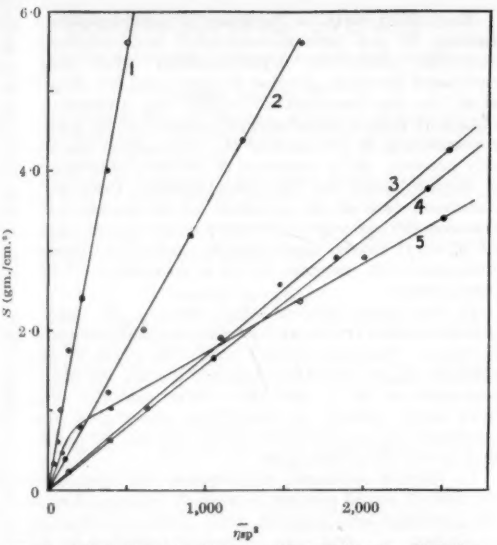


Fig. 1. Yield stress of sodium montmorillonite sols. Variation of $\bar{\eta}_{sp}$ with solids content (20° C.; *p*H 8·5): (1) Wyoming bentonite (ref. 3*a*); (2) clay *F* (ref. 3*d*); (3) clay *C* (ref. 3*c*); (4) clay *D* (ref. 3*c*); (5) hectorite (ref. 3*b*)

particular value of $c[\eta]$ are obtained with systems of large platelets, while needles and 'fluffy' platelets lead to weaker structures.

Heterocoagulation may be eliminated by heat treatment or by addition of certain anions that are strongly adsorbed on the positively charged edges of the clay platelets[4]. Addition of electrolytes such as sodium, calcium or aluminium chlorides to pre-solvated sodium montmorillonite sols, on the other hand, leads to rapid coagulation beyond some specific minimum electrolyte concentration, and results in a change-over from the 'house of cards' structure to an edge-to-edge association of clay platelets. The specific viscosity is reduced in the former systems, due to fall in the value of $[\eta]$; but the enhanced dissymmetry that results in the latter system leads to a marked overall rise in both specific viscosity and yield-strength.

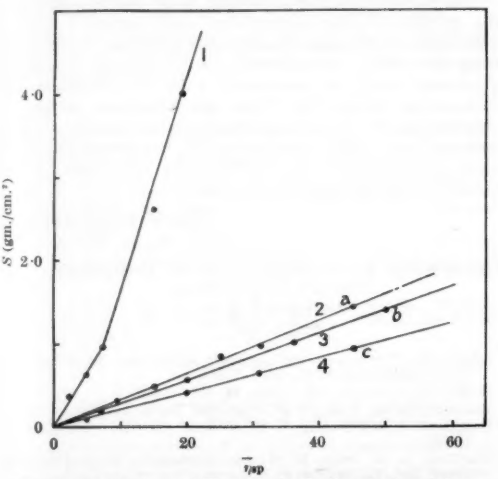


Fig. 2. Yield stress of Wyoming bentonite sols (non-heterocoagulated). Variation of $\bar{\eta}_{sp}$ with solids content (20° C.; *p*H 8·5): (1) no addition; (2) addition of 3 per cent carboxymethyl cellulose; (3) addition of 10 per cent 'Calgon'; (4) 2 hr. heat treatment at 95° C. *a*: c = 0·05 gm./ml.; *b*: c = 0·13 gm./ml.; *c*: c = 0·03 gm./ml.

In all such systems, S varies directly as $\bar{\eta}_{sp}$ over a wide range of conditions (c = 0–0·16 gm. per ml.; $\bar{\eta}_{sp}$ = 0–60; $[\eta]$ = 10–500); and (see Fig. 2)

$$S = g'\bar{\eta}_{sp} \qquad (4)$$

Similar results have been obtained with suspensions of the non-swelling calcium montmorillonites and kaolins.

g' increases in the same order as the constant g for heterocoagulated systems.

The experimental data clearly demonstrate that the yield stress of clay systems in which the internal attraction is mainly determined by short-range van der Waals forces varies directly as $\bar{\eta}_{sp}$ over a wide range of conditions. From equations (1) and (4) it is seen that at $C > 0{\cdot}02$ gm./c.c.,

$$S = g'k'c^2\,[\eta]^2 \qquad (5)$$

According to Simha[5], $[\eta]$ varies approximately as p^2 (where p is the anisometry); while in the more concentrated sols, C will vary inversely as the particle separation ($\bar{d}$); and (5) may be written in the form

$$S = g'k'\,[p^2/\bar{d}]^2$$

For a particular value of p, the shape factor (g') is greatest for plates, and increases in the order plates > needles > spheroids. Such a relation for the internal attraction in systems of anisometric particles had indeed be derived theoretically in a recent work by Vold[6].

The factors affecting the yield stress in heterocoagulated systems will be discussed fully elsewhere.

This communication is based on work carried out in the Clay Development Laboratory, F. W. Beck and Co., Ltd., to which thanks are due for permission to publish it.

A. Packter

11 Kyverdale Road, London, N.16.

[1] Packter, A., *Kolloid Z.* (in the press).
[2] Schultz, G. V., and Blatschke, F. J., *Z. phys. Chem.*, B, **50**, 305 (1941).
[3] (*a*) Shaw, B. T., *J. Phys. Chem.*, **46**, 103 (1942). (*b*) Bates, T. F., *Amer. Mineral.*, **35**, 463 (1950). (*c*) Robertson, R. H. S. (private communications). (*d*) Mathieu-Sicard, A., *et al.*, *Bull. Soc. Franc. Mineral.*, **74**, 439 (1951).
[4] Loomis, A. G., *Trans. Amer. Inst. Min. and Met. Eng.*, **142**, 86 (1941).
[5] Simha, R., *J. Coll. Sci.*, **1**, 356 (1950).
[6] Vold, M. T., *J. Coll. Sci.*, **5**, 451 (1954).

Carioazulene, Natural and Synthetic, derived from Caryophillene

In the fractionation of hydrocarbons found in Copaiba balsam, we have isolated, from a bluish fraction, at a boiling point of 130°–136° C., under 0·2 mm. pressure, a compound with the typical reactions of azulenes, and which we propose to call 'carioazulene'. In an attempt to establish if its formation results from dehydrogenation of caryophillene, we submitted the remaining isolated fractions, consisting of caryophillene, to a dehydrogenation process using, respectively, selenium, sulphur and palladium under pressure, in an autoclave.

It was found that all caryophillene fractions resulted in the formation of azulene, the most convenient method being that in which a palladium – carbon catalyst (containing 11·36 per cent palladium) in the proportion of 4·7 catalyst to 100 caryophillene is used. Carioazulene may also be obtained using sulphur as a dehydrogenizer, the best proportion being 10 sulphur to 100 caryophillene. In both processes, temperature was increased to 280°–300° C. for a period of 40 min., while the internal pressure of the autoclave gradually increased to 20–25 atmospheres, due to release of gas. The proportions of palladium and sulphur mentioned give the best results; if they are used in larger quantities, a polymer is produced. Of the two, the palladium – carbon catalyst furnishes the purer product.

At atmospheric pressure, selenium on asbestos heated to a temperature of 200° C., can be used. The results, as regards efficiency and purity, are much less satisfactory than those obtained with palladium – carbon or sulphur.

The caryophillene that fails to react, once the azulene has been extracted, can be used in new dehydrogenations and, when a palladium – carbon catalyst is used, the same portion may be employed again, always keeping the fixed proportion between catalyst and caryophillene. It is consequently preferable to proceed to successive operations using the same oil from which, by means of vacuum distillation, the resulting azulene is removed. Carioazulene concentrated fractions are purified in the usual manner, by means of acid treatments, by the formation of trinitrobenzenic derivatives and by passage through alumina columns.

Melting point of trinitrobenzoate (Kofler): 145°–147° C.
Trinitrobenzoate crystals: long reddish-purple needles.

These experiments are of special interest, because azulenes derived from natural products described until now possess the fundamental structure of *cyclo*pentano-*cyclo*heptane, whereas the carioazulene we have obtained probably originated from the *cyclo*pentano-*cyclo*octane fundamental hydrocarbon, clovene.

N. Botafogo Gonsalves
M. A. Reis Cavalcanti
Djalma Paiva

Organic Chemistry Laboratory,
Instituto Oswaldo Cruz,
Caixa Postal 926,
Rio de Janeiro, Brazil.
Aug. 23.

Urea Adducts of Glyceryl Esters

Glyceryl mono-esters are extensively used in the food and other industries, but the commercial products are often mixtures containing a range of fatty acids (free or combined), free glycerol and varying proportions of mono-, di- and tri-glycerides. The fractionation of such mixtures by classical methods is by no means easy, and in view of the importance of obtaining pure esters, we have investigated the possibility of fractionation with urea; the formation of adducts between urea and various lipids has proved of value in the purification of various fatty acids and related compounds[1].

We have been able to show that urea adducts can be formed with glyceryl mono- and di-esters as well as with methyl and other simple esters; similar results have been reported from other laboratories[2–4].

Beginning with a commercial preparation containing 39 per cent monostearin, and employing a stepwise extractive crystallization with urea in methanol solution, similar to that used by Abu-Nasr *et al.*[5] for the fractionation of fish oils, a fraction was obtained with a monostearin content of 86 per cent, representing 46 per cent of the monoglyceride originally present. By a variation of the urea concentration a higher yield of the monostearin fraction was obtained, but at the expense of the purity of the fraction (68 per cent). Martinez *et al.*[3], using mixtures of glyceryl esters, have also succeeded in producing monoglyceride samples up to a maximum of 74 per cent purity.

It has been shown[6] that mono-, di- and triglycerides can be fractionated by crystallization from solvents. Samples of the commercial glyceryl monostearate were therefore extracted with 90 per cent methanol at 30° C. and the soluble material treated with urea, giving a precipitate containing monostearin of 85 per cent purity (cf. original 39 per cent) in a yield of 79 per cent.

In further attempts to increase the monostearin content of the 85 per cent material, this was dissolved in methanol and treated with gradually increasing quantities of urea, the inclusion compounds being allowed to crystallize over a two-hour period. The most favourable results were obtained when the weight ratio of lipid, urea and methanol was 1 : 14 : 80; the lipid fraction in solution had a monostearin content of 90 per cent (in 83 per cent yield) in contrast to the precipitated lipid containing 58 per cent monostearin.

These latter experiments indicated that under the experimental conditions used the distearin was preferentially precipitated by urea. Some of the results of Martinez *et al.*[3] confirm this conclusion; but Heckles and Dunlap[4], in work with technical glyceryl monolaurate, concluded that inclusion compounds were more readily formed with the monoesters; they also showed that urea is of value in the separation of mixed monoglycerides containing fatty acids of different degrees of unsaturation.

The monostearin estimations were carried out by the method of Handschumaker and Linteris[7], which determines 1-monoglycerides only; recent work[8] has suggested that considerable amounts of 2-monoglycerides may be associated with the 1-isomer in commercial mixtures. Thus the fractions we have obtained of 90 per cent monoglyceride content could contain up to 10 per cent of 2-monoglycerides, although it seems improbable that the latter compounds form adducts with urea.

Francis Aylward
P. D. S. Wood

Department of Chemistry and Food Technology,
Borough Polytechnic,
London, S.E.1.
Sept. 16.

[1] Schlenk, H., "Progress in the Chemistry of Fats and Other Lipids", Vol. 2 (Pergamon Press, Ltd., 1954).
[2] Knight, H. B., *et al.*, *Anal. Chem.*, **24**, 1331 (1952).
[3] Martinez-Moreno, J. M., *et al.*, *Fette und Seifen*, **54**, 550 (1952).
[4] Heckles, J. S., and Dunlap, L. H., *J. Amer. Oil Chem. Soc.*, **32**, 224 (1955).
[5] Abu-Nasr, A. M., Potts, W. M., and Holman, R. T., *J. Amer. Oil Chem. Soc.*, **31**, 16 (1954).
[6] Feuge, R. O., and Gros, A. T., *J. Amer. Oil Chem. Soc.*, **27**, 117 (1950).
[7] Handschumaker, E., and Linteris, L., *J. Amer. Oil Chem. Soc.*, **24**, 143 (1947).
[8] Brokaw, G. Y., Perry, E. S., and Lyman, W. C., *J. Amer. Oil Chem. Soc.*, **32**, 194 (1955).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, January 23

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. R. J. F. Withers: "Logical Form and Explanation".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (joint meeting with the MEASUREMENT SECTION, at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. E. R. Wiblin: "Particle Accelerators".

PHARMACEUTICAL SOCIETY OF GREAT BRITAIN (at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Mr. G. R. A. Short: "Essential Oils and their Pharmaceutical Applications".

Tuesday, January 24

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. J. B. S. Haldane, F.R.S.: "The Second Indian Five-Year Plan".*

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. A. A. Lombard: "Low Consumption Jet Engines".

Wednesday, January 25

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Prof. V. B. Wigglesworth, F.R.S.: "Insect Physiology in Relation to Insecticides" (Fernhurst Lecture).

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Sympoalum on "Electronic Methods of Pictorial Reproduction".

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP and CHEMICAL ENGINEERING GROUP (joint meeting with the INSTITUTION OF CHEMICAL ENGINEERS, in the Large Lecture Theatre, King's College, Strand, London, W.C.2), at 6.30 p.m.—Dr. F. R. Himsworth and Mr. W. D. Clark: "Control of Corrosion in the Heavy Chemical Industry".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP—NUTRITION PANEL (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Third meeting in the new series "Nutrition Requirements and Food Fortification".

BRITISH PSYCHOLOGICAL SOCIETY, MEDICAL SECTION (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 8.30 p.m.—Prof. T. Ferguson Rodger: "The Other Man's Point of View".

Thursday, January 26

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. K. A. Sinnhuber: "Seashores, Mountains, and Forests: the Struggle for Living-Space in Middle Europe".*

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. B. F. J. Schonland, F.R.S.: "Benjamin Franklin—Natural Philosopher" (Wilkins Lecture).

MINERALOGICAL SOCIETY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—General Meeting.

INSTITUTE OF REFRIGERATION (at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Dr. H. I. Andrews: "The Development of a Steam Operated Refrigerator Van".

Friday, January 27

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Mr. D. A. Wrangham, Mr. R. McCrae and Mr. W. K. Rooney: "Sandwich Courses".

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (in the Lecture Theatre of the Mining Institute, Neville Hall, Newcastle-upon-Tyne), at 6.15 p.m.—Mr. C. E. Iliffe: "Nuclear Reactors for the Generation of Power".

SOCIETY FOR ANALYTICAL CHEMISTRY (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.45 p.m.—Annual General Meeting of the Microchemistry Group; 7.15 p.m.—Scientific Papers.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1); at 9 p.m.—Brig.-Gen. Sir Harold Hartley, F.R.S.: "World Needs and World Resources".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

RESEARCH FELLOW IN COSMIC RAYS at the University of Tasmania—The Registrar, University of Tasmania, Box 647C, G.P.O., Hobart, Tasmania (January 31).

SENIOR RESEARCH FELLOW (with an honours degree in psychology and preferably experience in children's work) IN THE DEPARTMENT OF CHILD HEALTH—The Secretary, The University, Aberdeen (January 31).

ASSISTANT LECTURER or LECTURER (with an honours degree and special qualifications and interests in either æsthetics and moral philosophy or the philosophy of science and mathematics) IN THE DEPARTMENT OF PHILOSOPHY—The Registrar, The University, Liverpool (February 3).

LECTURER or ASSISTANT LECTURER IN BIOCHEMISTRY—The Registrar, The University, Sheffield (February 4).

LECTURER (Grade II) or ASSISTANT LECTURER (Grade III), and a RESEARCH FELLOW, IN THE DEPARTMENT OF THEORETICAL MECHANICS—The Registrar, The University, Bristol 8 (February 10).

PHYSICIST or ELECTRICAL ENGINEER, Experimental Officer grade (with at least H.S.C. (science) or equivalent), at a Ministry of Supply Armament Research and Development Establishment, near Sevenoaks, Kent, for experimental design of electronic systems of V.T. Fuzes and associated trials equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.604/5A/BN (February 10).

LECTURER/SENIOR LECTURER (preferably with qualifications and interest in either the history and theoretical foundations of psychology or psychometrics and individual differences) IN PSYCHOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 11).

EXPERIMENTAL OFFICER (with at least H.S.C. (science) or equivalent), at the London Headquarters of the Ministry of Supply to carry out reorganization of electronic post-design service work in industry and to assist in implementation of packaging directives and in technical progressing of miscellaneous electronic equipment development contracts—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.586/5A/BN (February 14).

CHAIR OF APPLIED MATHEMATICS, CHAIR OF ATOMIC PHYSICS, CHAIR OF PHYSICAL CHEMISTRY, CHAIR OF PETROLOGY, CHAIR OF BIOLOGICAL OCEANOGRAPHY—The Dean, Faculty of Science, Alexandria University, Moharram Bey, Alexandria, Egypt (February 15).

LECTURER (Grade I or Grade II) IN THE DEPARTMENT OF PHYSICS—The Registrar, The University, Birmingham (February 18).

CHAIR OF PHARMACEUTICS at the School of Pharmacy—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 27).

HEAD (with high qualifications in geology and experience in both teaching and research) OF THE DEPARTMENT OF GEOLOGY—The Principal, Chelsea Polytechnic, Manresa Road, London, S.W.3 (February 28).

ASSISTANT LECTURER or LECTURER (with a degree or diploma in horticulture and sound practical experience) IN HORTICULTURE, at Canterbury Agricultural College, The University, Canterbury, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (February 29).

LECTURER IN AGRICULTURE, with particular reference to Ecological Land-use Survey, at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 29).

PROFESSOR OF EDUCATION, and HEAD OF THE DEPARTMENT OF EDUCATION, at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, February 29).

SENIOR LECTURER IN CLINICAL BIOCHEMISTRY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 29).

AIR POLLUTION ENGINEER (with a university degree in chemical technology or equivalent qualification and about twelve years experience in chemical engineering or allied activities) in the City Engineer's Department, Durban, South Africa—Messrs. Webster, Steel and Co., 3 St. Helen's Place, Bishopsgate, London, E.C.3 (March 16).

DIRECTOR (with high scientific attainments, preferably in fields related to soils or crops combined with administrative experience either as head or deputy in the organization and running of a research institute or university department) OF THE COCONUT RESEARCH INSTITUTE OF CEYLON—The Chairman, Coconut Research Board, Department of Agriculture, Peradeniya, Ceylon (March 31).

ANIMAL HOUSE/LABORATORY TECHNICIAN (male or female), to assist in experimental pathology in the Research Department—The Secretary and House Governor, Mount Vernon Hospital, Northwood, Middlesex.

ASSISTANT LECTURER, Grade B (with an honours degree in chemistry), IN THE SCHOOL OF CHEMISTRY—The Registrar, College of Technology and Commerce, The Newarke, Leicester.

ASSISTANT LECTURER (honours graduate) IN ZOOLOGY, and a RESEARCH ASSISTANT (honours graduate) IN ZOOLOGY—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1.

ASSOCIATE PROFESSOR OF MATHEMATICS in the University of Alberta—Dean W. H. Johns, Faculty of Arts and Science, University of Alberta, Edmonton, Alberta, Canada.

CHEMISTS (graduates, with or without research experience, mainly interested in physical and colloid chemistry)—The Director of Research, British Rubber Producers' Research Association, 48 Tewin Road, Welwyn Garden City, Herts.

ENGINEERS and PHYSICISTS (particularly with electronics), Experimental Officer and Assistant Experimental Officer grades, at Royal Naval Scientific Service Experimental Establishments in the London, Portsmouth and Weymouth areas, Gloucestershire and Scotland—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.214/5A.

EXPERIMENTAL OFFICER (with H.S.C. (science) or equivalent, and preferably some experience of equipment employed in machine telegraph systems including teleprinters) at a Royal Air Force Signal Establishment at Kidbrooke, to work in a small team engaged on the development of small electromechanical and electronic equipment associated with machine telegraph systems—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.585/5A/BN.

GEOCHEMIST (with a good honours degree in chemistry or equivalent and some experience in inorganic analysis with special reference to rock and mineral analysis) IN THE GEOLOGICAL SURVEY DEPARTMENT, Tanganyika—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.105/8/09.

LECTURER (male, with a degree in agriculture and some general experience in tropical agriculture) IN AGRICULTURE at the College of Agriculture, Mauritius—Director of Recruitment, Colonial Office, 2 Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.63/52/06.

MATHEMATICIAN (with an honours degree in mathematics) IN THE OPERATIONAL RESEARCH SECTION for work initially concerned with applying linear programming to problems of production scheduling, selection of order, etc.—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "O.R.4".

PHYSICIST (with academic qualifications of degree standard or equivalent) in the Research Department of the Bank of England Printing Works—Staff Manager, St. Luke's Printing Works, Old Street, London, E.C.1.

SENIOR TECHNICIAN (fully experienced in all branches of physics laboratory work, and, if possible, able to assist in general administration) IN THE PHYSICS RESEARCH DEPARTMENT—The Secretary Birkbeck College, Malet Street, London, W.C.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

United Kingdom Atomic Energy Authority. First Annual Report for the period 19th July, 1954–31st March, 1955. Pp. vii+35. (London: H.M. Stationery Office, 1955.) 2*s*. net. [1111

Ministry of Housing and Local Government. Scottish Office. The Surface Water Year-Book of Great Britain, 1945–53. (Hydrometric statistics for British rivers, together with related rainfalls, for the eight years ended 30th September, 1953.) Pp. xi+167. (London: H.M. Stationery Office, 1955.) 35*s*. net. [1111

Forestry Commission. Leaflet No. 36: The Crossbill. Pp. 11. 9*d*. net. Booklet No. 4: Rusts of British Forest Trees. By J. S. Murray. Pp. 15+8 plates. 2*s*. 6*d*. net. (London: H.M. Stationery Office, 1955.) [1111

Some Tasks and Perspectives in Physical Chemistry. By Prof. R. M. Barrer. (Inaugural Lecture, Tuesday, 24th May, 1955.) Pp. 13+4 plates. (London: Imperial College of Science and Technology, 1955.) [1111

Standardised Disinfectants Co., Ltd. Technical Bulletin: Dilstan Formulations of Dieldrin for Controlling Public Health and Industrial Pests. Pp. 12. (London: Standardised Disinfectants Co., Ltd.) [1111

Presentation of Technical Information Discussion Group. Group Paper No. D.G.5: Readability. By Susan R. Neuberger. Pp. 21. Group Paper No. D.G.6: The Function of a Technical Writer in Industry. By P. D. Patterson. Pp. 10. (London: University College London, 1955.) [1111

Manchester Public Libraries. The 103rd Report of the Libraries Committee, 1954–55. Pp. 29+4 plates. (Manchester: Manchester Public Libraries, 1955.) [1111

Fifth Annual Report on the Fulbright Program in the United Kingdom and Colonial Territories, 1949–1954. Pp. 184. (London: United States Educational Commission in the United Kingdom, 1955.) [1611

Ordnance Survey Annual Report, 1954–55. Pp. 24+10 plates. (London: H.M. Stationery Office, 1955.) 5*s*. net. [1611

Aero Research Technical Notes. Bulletin No. 153 (September, 1955): The Influence of Low Temperature on "Redux" Bonded Lap Joints. By A. Hartman. Pp. 10. (Duxford: Aero Research Ltd., 1955.) [1611

Air Ministry: Meteorological Office. Geophysical Memoirs. No. 96 (Fourth number, Vol. 12): The Free Atmosphere in the Vicinity of Fronts: Analysis of the Observations by the Meteorological Research Flight, 1950–52. By J. S. Sawyer. (M.O. 584d.) Pp. 24. (London: H.M. Stationery Office, 1955.) 5*s*. net. [1611

Bulletin of the British Museum (Natural History). Botany. Vol. 2, No. 1: New Himalayan Species of *Pedicularis*, with special reference to those from the Eastern Himalaya. By P. C. Tsoong. Pp. 1–34. (London: British Museum (Natural History), 1955.) 8*s*. [1611

Leeds City Museums. Annual Report of the Sub-Libraries and Arts (Museums) Committee to the Council for the year ended 31st March, 1955. Pp. 11. (Leeds: Leeds City Museums, 1955.) [1611

Journal of Analytical Psychology. Vol. 1, No. 1. Pp. 108. Subscription rate: 21*s*. per volume (at present 2 issues). Single issues, 12*s*. 6*d*. (London: Tavistock Publications, Ltd., 1955.) [1611

Planning. Vol. 21, No. 388 (November, 1955): Ownership of the Press. Pp. 209–224. (London: Political and Economic Planning, 1955.) 2*s*. 6*d*. [1611

Annual Report of the Director of the Meteorological Office presented by the Meteorological Committee to the Secretary of State for Air, for the year April 1, 1954, to March 31, 1955. Pp. 68. (M.O. 594.) (London: H.M. Stationery Office, 1955.) 2*s*. 6*d*. net. [1611

Current Status and Recent Progress of Printed Circuits in England. By Dr. Paul Eisler. (Presented at the Symposium on Printed Circuits, Philadelphia, Pa., January 20 and 21, 1955.) Pp. 10. (Reprinted from the Proceedings of the Symposium on Printed Circuits.) (London: Technograph Printed Circuits, Ltd., 1955.) [1611

British Cast Iron Research Association. Thirty-fourth Annual Report, for the year ending June 30th, 1955. Pp. i+15. (Alvechurch, Birmingham: British Cast Iron Research Association, 1955.) [2111

Institution of Gas Engineers. Publication No. 472: 16th Report of the Chairman's Technical Committee, 1954–55. Pp. 51. Publication No. 473: Recommendations to Prevent Accidents During the Cutting Out of Gas Mains for Repairs and Alterations, for Use with Cast Iron and Steel Mains with Pressures not exceeding 50 lb. per Sq. In. Pp. 10. Publication No. 474: Institution Gas Research Fellowship Report, 1953–54. The Fluidized Gasification of Coal. By Dr. B. H. Thompson and Dr. J. E. Garside. Pp. 25. Publication No. 475: 32nd Report of the Gas Education Committee, 1954–55. Pp. 25. Publication No. 476: Symposium on Coke. Pp. 69+1 plate. Publication No 477: The Tolerance of Aerated-Burner Appliances to Variations in the Combustion Characteristics of Town Gas. By G. H. Fuidge and Dr. J. R. Dewhurst. Pp. 57. Publication No. 478: Area Technical Services. By J. E. Davis. Pp. 23. Publication No. 479: Some Aspects of Research in the Petroleum Industry. By W. M. Catchpole. Pp. 28. Publication No. 480: Official Programme, 21st Autumn Research Meeting, London, 22nd and 23rd November, 1955. Pp. 8. (London: Institution of Gas Engineers, 1955.) [2111

Other Countries

Hamburger Sternwarte in Bergedorf. Jahresbericht der Hamburger Sternwarte in Bergedorf für das Jahr 1953. Pp. 5. Jahresbericht der Hamburger Sternwarte in Bergedorf für das Jahr 1954. Pp. 8. Katalog von 3356 schwachen Sternen für das Aquinoktium 1950 beobachtet an den Meridiankreisen der Sternwarten Hamburg-Bergedorf und Heidelburg-Königstuhl. Von J. Larink, A. Bohrmann, H. Kox, J. Groeneveld und H. Klauder. Pp. xxi+69. Zweiter Katalog der Astronomischen Gesellschaft für das Aquinoktium 1950 Örter der Sterne bis zur neunten Grosse zivischen dem Nordpol und 2° südlicher Deklination abgeleitet aus photographischen Himmelsaufnahmen der Sternwarten Bergedorf und Bonn, unter Leitung von Richard Schorr und Arnold Kohlschütter. Zehnter Band: Deklination +20° bis +25°, Bergedorf-Bonn. Herausgegeben von der Hamburger Sternwarte. Pp. iv+288. (Hamburg-Bergedorf: Hamburger Sternwarte, 1954.) [911

The Organisation of Applied Research in Europe: Proceedings of the Conference held at Nancy, 11th–13th October 1954. (Project No. 191.) Pp. 258. (Paris: Organization for European Economic Co-operation; London: H.M. Stationery Office, 1955.) 600 francs; 12*s*.; 2 dollars. [1111

Indian Forest Bulletin. (New Series, Botany.) No. 189: A Diagnostic Key to the Various Forms of Introduced Mesquite (*Prosopis Juliflora* D.C.) By M. B. Raizada and R. N. Chatterji. Pp. 6. (Delhi: Manager of Publications, 1955.) 9 annas; 10*d*. [1111

Commonwealth Scientific and Industrial Research Organization, Australia. Bulletin No. 276: An Analysis of the Records of the Registered Australian Merino Stud Flocks. By B. F. Short and H. B. Carter. Pp. 35. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1955.) [1111

Western Australia. Report of the Government Chemical Laboratories for the year 1952. (Extract from Mines Department Annual Report.) Pp. 12. (Perth: Government Printer, 1955.) [1111

Papers and Proceedings of the Royal Society of Tasmania. Vol. 89. Pp. xiii+355+15 plates. (Hobart: Royal Society of Tasmania, 1955.) 20*s*. [1111

Scientific Institutions and Scientists in Latin America. Vol. 2. Pp. iii+363. (Montevideo: United Nations Educational, Scientific and Cultural Organization, 1955.) [1111

Canada: Department of Mines and Technical Surveys. Geological Survey of Canada. Bulletin 29: Wall-Rock Alteration at Certain Lead-Zinc Replacement Deposits in Limestone, Salmo Map-Area, British Columbia. By L. H. Green. Pp. vi+33+3 plates. 75 cents. Bulletin 30: A Decrepitation Study of Quartz from the Campbell and Negus-Rycon Shear Zone Systems, Yellowknife, Northwest Territories. By R. W. Boyle. Pp. v+20. 50 cents. Bulletin 31: Mineralogy of Uranium Deposits, Goldfields, Saskatchewan. By S. C. Robinson. Pp. vii+104+24 plates. 75 cents. (Ottawa: Queen's Printer, 1954 and 1955.) [1111

Tanganyika. Records of the Geological Survey of Tanganyika. Vol. 2, 1952. Pp. 1+66+10 plates. (Dar-es-Salaam: Government Printer, 1955.) 8*hs*. 7/50. [1611

Mitteilungen des Deutschen Wetterdienstes. Nr. 14 (Band 2): Die Agrarmeteorologen-Tagung in Frankfurt a. M. vom 14 bis 17 März 1955. Pp. 210. (Bad Kissingen: Deutschen Wetterdienstes, 1955.) [1611

Canada: Department of Mines and Technical Surveys. Geological Survey of Canada. Memoir 278 (Supplement to Memoir 240): Palaeozoic Geology of the Windsor-Sarnia Area, Ontario. By B. V. Sanford and W. B. Brady. Pp. v+65. (Ottawa: Queen's Printer, 1955.) 75 cents. [1611

Imperial College of Tropical Agriculture. A Report on Cacao Research, 1954. Pp. 81. (Trinidad and London: Imperial College of Tropical Agriculture, 1955.) 12*s*. 6*d*. [1611

Changements dans la Faune des Papillons (macrolépidoptères) de Digne (Basses-Alpes). Par Gustav Lederer et Josef Leinfest. (Édition spéciale de *Entomologische Zeitschrift*. Traduit de l'Allemand et Preface par J. ël Propper, avec l'Autorisation des Éditions Kernen de Stuttgart.) Pp. 28. (Clermont-Ferrand: Joël Propper, 9 Rue de Risen, 1953.) [2111

Det Kongelige Industri-, Håndverk- og Skipsfartsdepartement. Norsk Polarinstitutt. Skrifter Nr. 108: Late-Pleistocene Deposits at Kapp Wijk, Vestspitsbergen. By Rolf W. Feyling-Hansen. Pp. 21+3 plates. (Oslo: Broggers Boktrykkeris Forlag, 1955.) 3 kronor. [2111

Catalogues

Eastman Organic Chemicals. General Price Revisions. Pp. 16. (Amendment No. 2, October, 1955.) (Kirkby, Liverpool: Kodak, Ltd., 1955.)

Loughborough Glass Company. General Laboratory Equipment. Pp. 43. (Loughborough: Loughborough Glass Co., Ltd., 1955.)

"E-MIL" Catalogue No. 7: Laboratory Glassware and Thermometers. Pp. 58. Price List for Catalogue No. 7. Pp. 24. (Treforest, Glam.: H. J. Elliott, Ltd., 1955.)

"VARIAC" Transformer Catalogue. Pp. 12. (London: The Zenith Electric Company, Ltd., 1955.)

Hilger Scientific Instruments, 1955. (CH 395/GB). Pp. 20. (London: Hilger and Watts, Ltd., 1955.)